APPLIED MECHANICS Reviews

A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

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GENERAL

Theoretical and Experimental Methods.. 284
Mechanics (Dynamics, Statics, Kinematics)........................ 286

MECHANICS OF SOLIDS

Servomechanisms, Governors, Gyroscopics........................ 287
Vibrations, Balancing.............. 288
Wave Motion in Solids, Impact........ 289
Elasticity Theory.................. 290
Experimental Stress Analysis.......... 291
Rods, Beams, Cables, Machine Elements. 292
Plates, Disks, Shells, Membranes....... 292
Buckling Problems.................. 294
Joints and Joining Methods........... 294
Structures......................... 295
Rheology (Plastic, Viscoplastic Flow).... 295
Failure, Mechanics of Solid State....... 297
Material Test Techniques............. 298
Mechanical Properties of Specific Materials........................ 298
Mechanics of Forming and Cutting...... 300

MECHANICS OF FLUIDS

Hydraulics; Cavitation; Transport...... 301
Incompressible Flow: Laminar; Viscous.. 302
Compressible Flow, Gas Dynamics..... 303
Wave Motion in Fluids.............. 304
Turbulence, Boundary Layer, etc....... 305
Aerodynamics of Flight; Wind Forces... 306
Aeroelasticity (Flutter, Divergence, etc.). 307
Propellers, Fans, Turbines, Pumps, etc... 308
Flow and Flight Test Techniques........ 310

HEAT

Thermodynamics................... 312
Heat and Mass Transfer............. 313
Combustion....................... 316

MISCELLANEOUS

Acoustics......................... 317
Ballistics, Detonics (Explosions)......... 318
Soil Mechanics, Seepage............. 318
Micromeritics..................... 319
Geophysics, Meteorology, Oceanography........................... 319
Lubrication; Bearings; Wear......... 320
Marine Engineering Problems......... 320

Letters to the Editor.... 320
Books Received.... 320

Marine Propulsion, Dr. H. W. Lerbs, 281

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APPLIED MECHANICS REVIEWS

VOL. 9, NO. 7 **MARTIN GOLAND** *Editor* JULY 1956

MARINE PROPULSION

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HAMBURG (GERMANY)

THIS article is intended to give a survey of results obtained in the field of hydrodynamics of marine propulsion. It is divided into the following parts: general propeller theory; theory of interaction between hull and propeller; and theory of the wake-adapted propeller as a combination of the first two parts.

I). GENERAL PROPELLER THEORY.

The central problem is the determination of the potential flow related to semi-infinite helical vortex sheets which are symmetrically spaced. The sheets are assumed to be built up by spiral vortex filaments of which both the diameter and the pitch remain constant when going aft. This restriction on the shape of the vortex sheets is permissible with "moderately loaded" propellers, i.e., with conditions for which second and higher powers of the induced velocity may be neglected. Relative to the radial coordinate, no restrictions on the shape of the sheets are imposed.

The velocity field of the filaments is determined first and that of the sheets is then obtained by an integration. There are two feasible ways to deduce the field of the filaments, viz., an integration of Laplace's equation or an application of the integral by Biot-Savart. Both ways are found in literature; the former in (1)* and (6), the latter in (2) to (6). For the axial and tangential velocity components induced at a bound vortex line, which are of main interest, the following expressions are obtained:

$$d\left(\frac{w_a}{v}\right) = \frac{1}{2}\, i_a \frac{dG}{dx_0}\,\frac{dx_0}{x - x_0} \qquad [1]$$

where $G = \Gamma/\pi D v$ represents the bound circulation at the radius $x_0 = r_0/R$ and where $x = r/R$ is the radial coordinate of the point of reference at the bound vortex line. An analogus expression is found for the tangential component when replacing the subscript a by t. By the "induction factors" i, the ratio of the velocity induced from a spiral filament to that from a straight line filament is established. The following expressions are deduced for these factors (1,6)

exterior field ($x > x_0$)

$$i_a = 2\left(\frac{x}{x_0} - 1\right)\left(\frac{z}{\tan\beta_i}\right)^2 A$$

$$i_t = \left(1 - \frac{x_0}{x}\right) z \left(1 + 2\,\frac{z}{\tan\beta_i}\,A\right) \qquad [2]$$

$$A = \sum_{m=1}^{\infty} m\, I'_{mz}\left(\frac{mz}{\tan\beta_i}\right) K_{mz}\left(\frac{mz}{\tan\beta_i}\,\frac{x}{x_0}\right)$$

interior field ($x < x_0$)

$$i_a = \left(1 - \frac{x}{x_0}\right)\frac{z}{\tan\beta_i}\left(1 - 2\,\frac{z}{\tan\beta_i}\,B\right)$$

$$i_t = 2\left(1 - \frac{x_0}{x}\right)\frac{z^2}{\tan\beta_i}\,B \qquad [3]$$

$$B = \sum_{m=1}^{\infty} m\, I_{mz}\left(\frac{mz}{\tan\beta_i}\,\frac{x}{x_0}\right) K'_{mz}\left(\frac{mz}{\tan\beta_i}\right)$$

The induction factors depend on the ratio x_0/x, the number of blades z, and the pitch angle β_i of the filament. They are independent of the circulation and are solely determined by the geometry of the vortex system. Numerical calculations have been carried out for $z = 3$ to 5 (6).

For a given distribution of the bound circulation G, the velocity components induced at the stations x of a bound vortex line may be obtained by an integration of [1]. An iteration becomes necessary since the induction factors depend on β_i, which is the pitch angle of the resultant relative flow at the bound vortex line, because of the following geometrical relation

$$\tan\beta_i = \left(1 + \frac{w_a}{v}\right)\Big/\left(\frac{x}{\lambda} - \frac{w_t}{v}\right)$$

$\lambda = v/\pi D n$ being the advance coefficient. The difficulty that the integral over [1] is an improper integral may be overcome by expanding the circulation G and the induction factors i into

*The numbers in parentheses refer to the list of references, the numbers in brackets refer to equations.

9th International Congress of Applied Mechanics

The National Science Foundation is planning to assist a limited number of engineers and scientists to attend the 9th International Congress of Applied Mechanics in Brussels, Belgium from September 5-13, 1956. Applications for these international travel grants should be submitted to the National Science Foundation, Washington 25, D. C., not later than August 1, 1956.

Fourier series (3,6). Having determined the induced velocity components, the force components acting on the bound vortex follow from the law by Kutta-Joukowsky.

The problem of the free-running propeller of minimum loss of kinetic energy is a special case of the afore-written general equations. In this case, the vortex sheets are of a true helical shape corresponding to a rule deduced by Betz (7). From this rule, the relation

$$(w_a/v) + (\lambda_i/x)\,(w_t/v) = w/v$$

follows within which the quantities λ_i and w are independent of the radius. Introducing expression [1], an integrodifferential equation for G is obtained

$$\int_{x_n}^{1} \frac{dG}{dx_0}\,\frac{1}{x - x_0}\left(i_a + \frac{\lambda_i}{x}\,i_t\right) dx_0 = 2\,\frac{w}{v} \qquad [4]$$

For given values of λ_i and w, the bound circulation of a free-running optimum propeller is ascertained from this equation (3). This permits a numerical calculation of the Goldstein factor κ, which plays an important role in the application of propeller theory and which is defined from Stokes' law by the relation

$$\kappa = (z\,G) \Big/ \left(2x\,\frac{w_t}{v}\right)$$

From both the integral equation and from [1] the function κ is obtained in a way which is independent of Goldstein's former analysis carried out on a basis of Betz' displacement theorem (8). Difficulties with slow convergence which arise with Goldstein's series expansions for great values of λ_i are avoided in numerical calculations when applying the integral equation.

For the case of vortex sheets of a true helical shape, i.e., for free-running optimum propellers, a relation between w_a and w_t is found from [1] to [3]. From this relation is follows that the resultant of w_a and w_t is perpendicular to the free vortex sheets in this case. This "condition of normality" together with the displacement theorem permit writing explicit expressions for the perturbation velocities w_a and w_t of a free-running optimum propeller.

The relations mentioned so far hold both for an airplane and a marine propeller. For the latter, however, the replacement of a blade by a line vortex does not suffice because its aspect ratio is usually small. This arises from the requirement to avoid the onset of cavitation, from which condition an upper limit for the lift coefficient follows. Replacing a blade by a lifting surface instead of by a lifting line introduced a boundary-value problem, viz., to determine the shape and the angle of attack of a skeleton such that a prescribed pressure distribution is realized in the propeller flow. This problem is treated in a direct way by calculating the velocity components induced from the free and bound vortex sheets at several stations of the chord length and satisfying the boundary condition at these stations (4,5). In an approximate method, one starts from a skeleton which generates the given pressure distribution in two-dimensional flow. The propeller flow requires corrections on both the shape and the angle of attack of this skeleton which follow from the curvature of the propeller flow at the halfway point (9) and, applying Weissinger's lifting-surface theory, from the boundary condition at the ¾-point (10).

Marine propellers differ from airplane propellers also relative to the hub-diameter ratio which is greater for the former. This requires the boundary condition to be satisfied at the hub. Attempts to determine the order of magnitude of this perturbation are found for the field of the free vortex sheets in (6) and for that of the bound vortexes in (11).

II). THEORY OF INTERACTION BETWEEN HULL AND PROPELLER.

In the modern approach the problem is split up into potential and viscous flow phenomena (12), taking into consideration the interference between them. For the interaction arising in potential flow, singularity methods are applied, i.e., both the hull and the propeller are replaced by proper singularities from which both the perturbation velocities created by the hull (wake) and the interaction force between hull and propeller (thrust deduction) are determined, the latter by means of Lagally's theorem. This concept is expressed first in (13) and is then extended in subsequent papers (14 to 18). Considering the simple case of a deeply submerged body of revolution, axially distributed sources and sinks are suitable to substitute for the hull. The perturbation of these singularities at the location of the propeller determines the "nominal potential wake." To replace the propeller by simple singularities, infinitely many blades are assumed. This permits the propeller to be represented by cylindrical sheets of both ring vortexes and straight line vortexes. The latter may be neglected since the tangential component of the induced velocity is of minor interest in these considerations. To further simplify, a propeller of a constant bound circulation is assumed with which a single sheet of ring vortexes in the boundary of the slipstream is associated. Relative to the inflow, this sheet of ring vortexes is equivalent to a uniform distribution of sinks on the propeller disk which may be replaced by a point sink in the propeller center if the action at large distances ahead is considered. The interaction of this point sink with a dipol, which in a superimposed uniform flow replaces a sphere, gives the following fundamental relation (13)

$$t_p = \rho\,E\,u_p/T = 2\,w_p/[1 + (1 + c_T)^{1/2}] \qquad [5]$$

The notation is as follows:

t_p = potential thrust deduction = $\Delta R/T$, E input of the sink (which is related to the loading coefficient of the propeller, $c_T = T \Big/ \frac{\rho}{2}\,v_S^2 F$, T thrust, v_S ship speed, F propeller disk area, w_p = potential wake fraction = u_p/v, u_p induced velocity at the sink.

It has been noted that data obtained experimentally for t are appreciably greater than the theoretical result. A possible reason for this discrepancy is that for w_p the nominal wake is introduced which amounts to a neglect of the image of the propeller singularity into the hull. In (16), the problem of sphere-point sink interaction is treated taking into account the image of the sink into the sphere by means of Weiss' sphere theorem. This changes the perturbation at the location of the propeller from the "nominal" to the "effective potential wake," the latter including the effects from both the hull singularities and the image. The following relation between effective and nominal wake is obtained in (16)

$$w_{pe} = w_{pn}\left\{1 + \frac{E}{36\pi v}\left(\frac{w'_{pn}}{w_{pn}}\right)^2 [w_{pn}^{2/3} - 1]^{-2}\right\} \qquad [6]$$

w'_{pn} being the derivative of the nominal wake fraction in the axial direction. The expression shows that the effective wake is greater than the nominal wake.

The application of these fundamental considerations to propeller problems requires the dependence of t_p and w_{pe}/w_{pn} on the radius to be known, i.e., to extend the singularity of the propeller from a point sink to a sink disk of an axis symmetrical input. Even in such a simple case as a sphere, great complexity is encountered in finding the image of such singularity systems. An important contribution to this problem is given

in (17). In this paper, the images of a uniformly loaded disk and of specific types of nonuniform distributions in the presence of a sphere are derived. Further, to gradually approach a realistic representation of a propeller, its helical shaped free vortex sheets are replaced by the simpler model of an infinite number of equidistant circular vortex disks with an axially symmetric distribution of circulation and their image into a sphere is represented. Finally, a gradual refinement of body shapes approaching more realistic forms of vessels is undertaken. Besides into spheres, the images of several types of singularities into both the prolate and the oblate spheroid have been investigated. It is hoped that the results derived in this paper will eventually lead to a satisfactory analytical solution of the problem of body-propeller interaction in potential flow and of the related problem of the wake-adapted propeller.

In (18), the interaction theory is developed in the form of a computational procedure on a basis of the singularity concept. The paper is concerned with the case of an axisymmetric flow. To approximate the effect of the propeller, infinitely many blades are assumed and the radial distribution of the bound circulation is replaced by a rectangular one. Correspondingly, two free vortex sheets of different diameter, each consisting of a semi-infinite row of ring vortexes, are introduced of which the induced velocity is derived from Laplace's equation. The body of revolution, of which only the shape of the stern portion is significant for the present problem, is approximated by a limited number of axially distributed point sinks and one point source. The boundary condition is satisfied at an equal number of arbitrarily chosen control points on the surface of the body, which gives a sufficient number of linear algebraic equations for the strength of the sinks. Taking into account the velocities induced from the propeller on the control points modifies the strength of the sinks by an amount which arises from the action of the image of the propeller system. In this way, both the nominal and the effective potential wake are obtained when calculating the perturbation in the plane of the propeller from the original and from the modified sink distribution, respectively. The thrust deduction force is determined in two ways, viz., on the basis of Lagally's theorem from the perturbation velocities of the propeller on the body sinks and, alternatively, using surface pressure integration. The numerical results indicate that, for the example treated, both wake fraction and thrust deduction are not sensibly modified by the action of the propeller. It is interesting to note how rapidly the thrust deduction force decreases on the body when the distance from the propeller increases. The first two sinks nearest to the propeller contribute 53%, the first three 74% and the first four sinks (situated at 0.98, 0.96, 0.93 and 0.88 body length) 90% of the total force.

It should be mentioned that it does not mean any considerable complications in this computational procedure to take into account the effect of the wave system on wake and thrust deduction. Further, an extension of the calculations to three-dimensional bodies is contemplated which will shed some light on the dependence of the thrust deduction on a circumferentially nonuniform inflow into the propeller.

As far as a nonviscous fluid is concerned, singularity methods have proven successful in coping with the problem of body-propeller interaction. The situation is less satisfactory in the case of a viscous fluid. Although the fundamental difference in the interaction for potential and viscous flow has long been recognized (12,19), the methods to establish analytical expressions for the frictional parts of both the wake and the thrust deduction can not yet be considered sufficiently accurate. Attempts to deal with this problem are found in (13), (16), and (18). The underlying assumption in these papers is that potential flow effects and boundary-layer effects may be evaluated separately and may be considered as being additive. Interference effects, namely the modification of the boundary layer by the pressure gradient of the propeller inflow and the modification of the potential flow by the displacement thickness of the boundary layer, are discussed but have not been formulated.

The conclusion is that the relations between the total values of either nominal and effective wake or thrust deduction and wake are not yet sufficiently known. With respect to the latter, the following semi-empirical expression is used in design work (20)

$$(1 - t)/(1 - t_0) = [(1 - w)/(1 - w_0)]^{0.25} \qquad [7]$$

t_0 and w_0 being average values which are ascertained by an analysis of a self-propulsion test.

In spite of the imperfections of the existing theory of hull-propeller interaction, it has proven of greatest value in explaining experimental findings on the thrust deduction which can not be understood otherwise. In recent work on the scale effect of propulsion coefficients (21), the result has been obtained that the thrust deduction coefficient increases when the scale of the model is increased and that it decreases for the same model when the roughness of the model surface is increased. The explanation follows from the interplay of the displacement thickness of the boundary layer with the sinks in the stern of the body. To maintain the boundary condition on the "effective hull," i.e., on the surface of the body augmented by the displacement thickness, the sinks in the afterbody become more feeble when the displacement thickness becomes greater, and vice versa. Reducing the input of the sinks decreases the interaction force (and vice versa), which gives the explanation for the afore-mentioned experimental results.

III). THEORY OF THE WAKE-ADAPTED PROPELLER.

The available theory is based on a steady relative flow, i.e., the wake is assumed to depend only on the radius. The bound circulation is to determine such that the useful power of the system "ship and screw" becomes a maximum value for given quantities of power input, advance ratio, and wake distribution. The optimum condition reads to the first order of the induced velocity, i.e., for a moderately loaded propeller, as follows (6)

$$\tan \beta_i / \tan \beta = k\,[(1 - t)/(1 - w)]^{0.5} = kF(x) \qquad [8]$$

where both $\tan \beta = \lambda_S(1 - w)/x$ and $\lambda_S = v_S/\pi nD$ are given quantities, and where k is independent of the radius. It follows from this relation that the free vortex sheets of an optimum wake propeller are not of a regular helical shape but that the pitch of the sheets depends on the radius and is determined by the functions t and w. As a consequence, the condition of normality is not satisfied with this type of propeller.

Combining the optimum condition with the geometrical relation

$$\tan \beta_i = \left[(1 - w) + \frac{w_a}{v_S}\right] \Big/ \left[\frac{x}{\lambda_S} - \frac{w_t}{v_S}\right]$$

and expressing the components of the induced velocity by their respective induction factors, an integrodifferential equation for the bound circulation of the optimum wake propeller is obtained (6)

$$\int_{x_n}^{1} \frac{dG}{dx_0}\left[\frac{i_a}{k} + F(x)\, i_t\right] \frac{dx_0}{x - x_0} = 2\left[F(x)\frac{x}{\lambda_S} - \frac{1 - w}{k}\right] \qquad [9]$$

An approximate solution of this equation becomes possible when developing both G and the induction factors into Fourier

series. A set of linear equations for the coefficients of G then follows.

The case of the system "hull, propeller, rudder" has not yet been treated rigorously. Preliminary studies for an approximate solution are indicated in (16). The presence of the rudder requires additional singularities which depend on the velocities induced at the surface of the rudder from both the hull and the propeller. These singularities will modify both the relation between t and w and the optimum function $F(x)$. A further modification of these relations will arise when taking into account the circumferential nonuniformity of the wake. This leads to a nonsteady propeller problem of which no solution is known in literature.

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"Letters to the Editor" and "Books Received for Review" now appear after the reviews

Theoretical and Experimental Methods

(See also Revs. 2099, 2107, 2108, 2121, 2139, 2142, 2182, 2263, 2288, 2294, 2303, 2311, 2327, 2328, 2361, 2362, 2395, 2401, 2407)

2076. Bandyopadhyay, G., and Narasimhan, R. K., Special types of group relaxation for simultaneous linear equations, *Quart. J. Mech. appl. Math.* **9**, 1, 122–128, Mar. 1956.

In this method, one of the residuals is liquidated and kept at its zero value while new groups are formed. The remaining residuals are gradually liquidated by a suitable choice of groups or combination of them. Method is dependent upon individual skill and practice and makes it possible to obtain final values in a shorter time, especially for ill-conditioned equations, than with conventional procedures.

C. B. Ludwig, USA

2077. Garza, A. de la, Error bounds for a numerical solution of a recurring linear system, *Quart. appl. Math.* **13**, 4, 453–456, Jan. 1956.

In the finite difference treatment of linear elliptic partial differential equations involving the Laplacian operator with boundary values specified on a closed curve, the governing equation and boundary conditions are approximated by a set of linear simultaneous algebraic equations. When these equations are solved approximately (e.g., by relaxation), there are equation residuals. This paper describes a method for bounding the error in the solution of the algebraic equations in terms of the residuals. A typical result is that, for Laplace's equation in a square with a 10×10 network, the maximum solution error cannot be more than 8 times the maximum residual. With a 20×20 network, the maximum solution error can be as much as 29 times the maximum residual.

S. H. Crandall, USA

2078. Granat, Yu. L., Iterational scheme of calculation of the roots of algebraic equations of higher order and construction of transition points (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* no. 20, 168–176, 1954.

In this article, author gives the iterational scheme of calculation of roots of algebraic equations, all roots of which are distributed in a half plane. It is possible to satisfy this condition for every algebraic equation by means of transformation of the coordinate system.

Author used Horner's method of division of the polynomial by a binomial for the calculation of the one real root. He also develops Horner's scheme for the case of division of the polynomial by a quadric trinomial for calculation of the pairs of the roots. These schemes can be applied in the operational calculus.

T. Riabokin, USA

2079. Morris, J., and Head, J. W., Polynomial characteristic equations. Criteria for quadratic factors to be positive, *Aircr. Engng.* **27**, 322, 419–420, Dec. 1955.

The requirements for an algebraic expression of even degree, in m say, to consist wholly of positive quadratic factors are: (1) All the coefficients of powers of m must have the same sign. (2) The two expressions in m^2, formed respectively by taking the terms of odd degree, divided by m, and the terms of even degree, must have all their zeros in m^2 real and negative; and furthermore, the zeros of these expressions must separate or straddle each other, as the case may be.

From authors' summary

2080. Voronovskaia, E. V., On a modification of Chaplīgin's method for differential equations of the first order (in Russian), *Prikl. Mat. Mekh.* **19**, 1, 121–126, 1955.

The numerical integration of differential equations introduced by Chapligin in 1950 is very interesting from the point of view of the exceptionally rapid convergence of the approximations. However, in the process of iteration, the computations even of the second approximation become complicated and cumbersome and the method is not practical. Using the excellent basic idea of Chapligin, author proposes a procedure which simplifies the integration and makes the method acceptable for engineering purposes. Four examples are given and the errors are estimated to vary between 0.0007 and 0.005.

M. Maletz, USA

2081. Slobodianskiĭ, M. G., Approximate solution of a self-adjoint boundary-value problem for an ordinary differential equation and determination of eigenvalue distribution regions (in Russian), *Prikl. Mat. Mekh.* **18**, 5, 585–596, Sept.–Oct. 1954.

Presupposing all eigenvalues positive, author estimates first eigenvalue from below by means of a splitting method applied to a suitably modified Green function and an inequality derived in a previous paper [AMR **7**, Rev. 680]. The resulting lower bound involves a trial function v_n of an associated problem and a free constant, the latter being determined as root of a quadratic. A somewhat ambiguous recurrence procedure is described to improve the lower bound, but the first step even with $v_n \equiv 0$ yields an error of only 5% in some instances, if checked versus Ritz-Galerkin estimates from above.

Furthermore, an approximative solution of the inhomogeneous equation is given together with an estimate of its error.

Second and higher eigenvalues, too, are accessible to method outlined, if the previous ones are known with sufficient accuracy.

Applicability is a little restricted by assumed vanishing boundary

...lues, but paper certainly has practical significance.

G. Plato, Germany

2082. Yakubovich, V. A., Estimate of characteristic exponents for a system of linear differential equations with periodic coefficients (in Russian), *Prikl. Mat. Mekh.* **18**, 5, 533–546, Sept.–Oct. 1954.

Author considers a system of linear differential equation expressed in vectorial form as

$$\frac{dx}{dt} = A(t)x$$

where x = vector and $A(t) = A(t + \omega)$, a matrix of the n^{th} order, with all the elements periodic functions of the period ω. The following theorem is proven:

(a) If λ_1, λ_2 are characteristic exponents of a system corresponding to the minimum and maximum real parts, then

$$\left(\frac{1}{2\omega}\right) \int_0^{\omega} q_1 dt \leq Re\ \lambda_1 < \left(\frac{1}{2\omega}\right) \int_0^{\omega} q_1 dt$$

and

$$\left(\frac{1}{2\omega}\right) \int_0^{\omega} q_2 dt - \epsilon < Re\ \lambda_2 \leq \left(\frac{1}{2\omega}\right) \int_0^{\omega} q_2 dt$$

where $Re\,\lambda$ represents the characteristic values in Liapunov's system of equation.

Author treats the cases for λ_1 real and λ_2 complex, and λ_1 and λ_2 complex. A system of two equations with real coefficients is examined: $\frac{dz}{dt} = JH(t)z$ where $H(t)$ is a symmetric matrix

$$H(t) = \begin{pmatrix} \alpha(t) & \beta(t) \\ \beta(t) & \gamma(t) \end{pmatrix}$$

and

$$\left(J = \begin{matrix} 0 & -1 \\ 1 & 0 \end{matrix}\right) \quad \left[JH(t) = A(t) - \left(\frac{SpA}{2}\ E\right)\right]$$

From this system the following lemma is derived: If $\chi_1(\lambda_1\beta) \leqslant \sigma_1$, $\chi_2(\lambda_1\beta) \leq \sigma_2$, $(0 \leq \sigma_{1\ 2} \leq \pi)$ are assumed to be valid for $\cos\sigma_1 + \cos\sigma_2 > 0$, then it follows that the inequality

$$\mathrm{ch}(\lambda\omega) \leq \frac{1 + \cos(\sigma_1 - \sigma_2)}{\cos\sigma_1 + \cos\sigma_2}$$

The final theorem is: Let the quadratic form $(H(t)c, c) \geq 0$ for $0 \leq t \leq \omega$, then

(1) if $n = 0, 1, 2, \ldots\ldots\ldots$

$$n\pi < m_- \leq M_+ < (n + 1)\pi$$

then all solutions for $\frac{dz}{dt}$ are bounded by $-\infty < t < +\infty$

(2) if $(n - 1)\pi < m_- \leq n\pi \leq M_+ < (n + 1)\pi$

$$\cos(M_+ - n\pi) + \cos(n\pi - m_-) > 0$$

then
$$\mathrm{ch}(\lambda\omega) \leq \frac{1 + \cos(M_+ + m_-)}{\cos(M_+ - n\pi) + \cos(n\pi - m_-)}$$

(3) if

$$(n - 1)\pi < m_+ \leq n\pi \leq M_- < (n + 1)\pi$$

then the system of equations for $\frac{dz}{dt}$ has an unbounded solution $(\lambda > 0)$

and
$$\mathrm{ch}(\lambda\omega) \leq \frac{1 + \cos(M_- + m_+)}{\cos(M_- - n\pi) + \cos(n\pi + m_+)}$$

Reviewer believes that while the quality of the paper is worthwhile mathematically, the practicality and engineering applicability is somewhat in doubt. The paper is difficult to follow terminologically.

N. M. Matusewicz, USA

2083. Glantz, H., and Reissner, E., On finite sum equations for boundary value problems of partial difference equations, *J. Math. Phys.* 34, 4, 286–297, Jan. 1956.

Authors consider a two- and a three-dimensional mixed boundary-value problem involving the corresponding two- and three-dimensional Laplace equations which arise in incompressible fluid flow. The method used differs from the usual procedure in the following way: instead of reducing the partial differential equation to an appropriate integral equation which is usually solved approximately, authors first approximate the boundary-value problem by a finite difference equation problem and then reduce it to a system of linear algebraic equations which can be solved exactly. For the two problems mentioned above, the relative finite-sum equations are obtained and interpreted. The method employed appears to be a useful addition as well as alternative to the usual procedure.

E. J. Scott, USA

2084. Shamanskii, V. E., Method of approximation in solving the Dirichlet problem for the Laplace equation (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **100**, 6, 1049–1052, 1955.

In this article, author gives an approximate solution to the Dirichlet problem for the Laplace equation in a two-dimensional domain. For this purpose he uses a method which gives the possibility of treating the given domain as the sum of subdomains for each of which the solution of Dirichlet's problem is easy.

Construction of the solution by this method leads to a system of the linear algebraic equations.

T. Riabokin, USA

2085. Conte, S. D., and Reeves, R. F., A Kutta third-order procedure for solving differential equations requiring minimum storage, *J. Assn. Comp. Machy.* **3**, 1, 22–25, Jan. 1956.

Author develops a modification of the Runge-Kutta third-order procedure for solving a system of N differential equations of first order, which reduces the number of required storage registers in a computer from $3N + A$ to $2N + A$, where A is a constant large enough to include the program.

H. Polachek, USA

2086. Henrici, P., Automatic computations with power series, *J. Assn. Comp. Machy.* **3**, 1, 10–21, Jan. 1956.

Power series are not only an important theoretical tool in many branches of classical analysis but they can also be used advantageously for various numerical purposes. Functions originally defined as solutions of differential equations or by definite integrals can frequently be represented by (convergent or divergent) power series in regions where the evaluation by other methods meets with great difficulties. An unwelcome feature of the formal calculations is their complexity, which often increases rapidly with the number of terms considered. With the advent of modern high-speed computing machinery, at least part of this complicated algebraical work can be automatized. This paper describes a code which was written for a specific computer (SEAC) for the use of power series in the solution of problems. Specific examples of solutions are given, such as combinatorial analysis, asymptotic expansions, computation of orthogonal polynomials from generating functions, and differential equations.

R. K. Neumann, USA

2087. Bukovics, E., Development of computing machines and their effect upon the technique of mathematical methods (in German), *Öst. Bauzeitschr.* **10**, 10, 188–194, Oct. 1955.

After reviewing the steps involved in the mathematical formulation and the numerical solution of a physical problem, author explains the general characteristics and mode of operation of digital computers. Included is a discussion of the considerations which enter into the selection of a numerical procedure appropriate for use with automatic computers. Paper should be useful to beginners in the field of high-speed computation.

A. S. Veletsos, USA

2088. DeCarlo, C. R., Computers and production engineering, ASME Ann. Meet., Chicago, Ill. Nov. 1955. Pap. 55-A-161, 10 pp.

During the past several years, considerable interest has been centered upon the possible use of the electronic automatic digital computer as an instrument in production management. Although in practically all cases the machines were originally installed for engineering and scientific calculations, production managements were soon to realize the possible benefit that might accrue from using such a device in the solution of complex production problems. Indeed, most of the large computers procured to date by industry—aside from those to be used in large paper-handling applications, such as life insurance premium notices, public utility billing, and integrated accounting operations—are to be used in solving problems affecting real production, inventory, and distribution operations.

From author's summary

2089. Lotkin, M., Some problems solvable on computing machines, *Comm. pure appl. Math.* **7**, 1, 149–158, Feb. 1954.

2090. Patterson, R. T., An inexpensive analogue computer for solving wind-tunnel strain-gage equations, *David W. Taylor Mod. Basin Rep.* 904, 23 pp. + 14 figs., 1 table, June 1954.

A comparatively cheap analog computer for use in the supersonic wind tunnel is designed and tested. It is a manual type to reduce wind-tunnel six-component strain-gage data to coefficient form, based on the principle of Fritz described in *Rev. sci. Instrum.* **23**, 667–671, 1952. Eight linear equations are solved with less than 0.2% error and the computer cost is less than $400, including one oscilloscope. One data point per minute is required. An automatic plotter to be interchangeable with the present manual answer unit is said to be under construction.

M. Sanuki, Japan

2091. Banerji, S. K., Solution of problems by the analogue method, *Bull. Calcutta math. Soc.* **47**, 1–8, Mar. 1955.

Mechanics (Dynamics, Statics, Kinematics)

(See also revs. 2106, 2119, 2147, 2148, 2162, 2206, 2230, 2251, 2299)

2092. Strigl, G., The nonlinear superposition principle for the solution of compound stability problems with branching points (in German), *Stahlbau* **24**, 2, 3; 33–39, 51–61, Feb., Mar. 1955.

In problems of stability to be solved on the basis of the theory of second order, the linear superposition principle is not applicable; the solution cannot be obtained directly from the solutions attained for the superposed loads. The approximate interpolation formulas (Dunkerley) do not always give satisfactory solutions. To avoid the cumbersome solution of the differential equation that describes the loading composed of superposed loads, author investigates the relationships existing in problems of the theory of second order in the case of two superposed loads P and K.

Points corresponding to related loads P and K producing change of stability in a system of coordinates (P,K) are located on a curve concave toward the point of origin. This curve intersects axes P and K at points $P_0(K = O)$ and $K_0(P = O)$ designating proper values. The curve is always comprised in the triangle included by tangents drawn at points P_0 and K_0 and the Dunkerly straight line connecting these points.

Author demonstrates the determination of the points of intersection of the two tangents with the other axis by the aid of the Rayleigh coefficient and by exchanging the known functions. If the two tangents thus determined deviate but little from the Dunkerly straight line, the latter may be accepted as a solution. In the contrary case, the accurate solution has to be determined from the elastic line of the composite problem, which latter develops by the superposition of all known functions of the two part problems. Author thus produces the ordinate of the elastic line by summation of two infinite series. Members of this series are determined by the use of the principle of Vianello on the basis of the "theory of first order" by stepwise advancing. The condition of buckling has to be equally satisfied independently of the locus of w which is possible if all coefficients of the condition equation equal zero. This condition results in a homogeneous system of linear equations, the determinant of the denominator of which equated to zero leads to the equation, whose solution for given P and K yields safety against buckling ν or, by substitution of $\nu = 1$, the related values P and K sought for. The determinant of buckling giving the solution consists, in effect, of infinitely numerous elements, but it can be demonstrated that the series forming the basis converge very well, and, for practical calculation, it is sufficient to consider very few members of the series.

In calculating statically indeterminate systems by the theory of second order, in the same manner as in calculation according to the theory of first order, the force method as well as the strain method can be applied. Author presents the application of both methods to statically indeterminate girders.

The numerical examples presented illustrate the theory and the good convergence as compared with the results obtained with the accurate solution of the differential equation of the entire problem. If only the first members of the series are considered, the error is 2–3%, but consideration of the first two members reduces the error to less than 0.1%, that is, to a practically acceptable value. This is also the yardstick of the utility of the procedure, for consideration of even three members renders it very cumbersome.

I. Korányi, Hungary

2093. Hinkle, R. T., Ip, C., and Frame, J. S., Acceleration in mechanisms, *J. appl. Mech.* **22**, 2, 222–226, June 1955.

Using a three-link direct contact mechanism, authors develop equations for finding the instantaneous radii of curvature for the paths of relative motion described by the coincidental points of contact in such mechanism. Method is based on use of equivalent linkages for the direct contact mechanisms. A graphical method for determination of these radii is also presented, and mathematical proof for the construction is given. Proof of the validity of the method of equivalent linkages is included as well as several illustrative problems.

In all, four theorems are stated which deal with the following: (1) Acceleration of the moving point of contact; (2) radius of curvature of the path of contact; (3) distance between the point of contact and the instant center for the two contacting links; and (4) angular acceleration ratio for the two links in contact.

A. G. Sharp, USA

2094. Semenov, M. V., Analysis of a special case of steady periodic motion in mechanisms (in Russian), *Trudi Inst. Mashinoved.* **15**, 57, 27–37, 1955.

Reciprocating motions in the particular cases where they occur with their moments and forces depending only on the angle of phase, rather than on the rotational speed, are analyzed by the application of an E-I diagram having for coordinates the kinetic energy and the moment of inertia of the system. The method achieves results said to be obtainable by other previously accepted methods, but author claims great reductions in the labor involved and in the errors of approximation.

No practical development of the study is given and the exposition is kept on a strictly academic level.

B. Posniak, USA

2095. Fonda, A. G., A study of simulators for the lateral motions of an automobile, *Cornell aero. Lab. Rep.* YA-804-F-2, 47 pp., Oct. 1954.

Two simulators useful for computing responses, one mechanical and the other using electronic analog computer elements, are described. A third simulator for demonstration of principles is included.

From author's summary by E. G. Newman, USA

2096. Rumiantsev, V. V., Equations for the motion of a solid body having cavities not fully filled with liquid (in Russian), *Prikl. Mat. Mekh.* **18**, 6, 719–728, 1954.

The problem of motion of a solid body with cavities completely filled with an incompressible liquid was studied extensively at the end of the last century by N. E. Zhukovskiĭ [Sobr. sochin., vol. 2, pp. 152–309, Gos. Izdat. Tekh. Teor. Lit., Moscow-Leningrad, 1949]. In recent years, small oscillations about equilibrium positions of solids with cavities not fully filled with liquid have been discussed.

In the present paper, the principle of least action in the form of Ostrogradskiĭ-Hamilton is applied to a system consisting of a solid body and a homogeneous incompressible liquid partially filling the cavities of the body. The differential equations of motion of such a system are obtained, and, under certain assumptions, the existence of several first integrals of these equations is shown.

E. Leimanis, Canada

2097. Thamm, I., Determination of the critical speed of the first order of Sharpless supercentrifuges equipped with vertical axis (in Hungarian), *Gep* **7**, 8, 309–319, Aug. 1955.

Critical speed of a given equipment is examined by a known method. The rotor is replaced by a single-mass rotating system with flexible bearings at the ends. The unknown quantities are determined with the aid of the swingperiod of the rotor hung as a gravity pendulum in place of one bearing. The simplifying conditions used are justified by the excellent agreement between the calculated and experimental data. The expression of the critical speed is given also in the case where one of the bearings is completely rigid.

The article is very clear, systematic, and specially exemplary to engineers in the determination of the simplifying conditions. There are some insignificant misprints in the paper.

G. Pattantyús, Hungary

Servomechanisms, Governors, Gyroscopics

(See also Rev. 2358)

2098. Reeber, R., Contribution to the question of optional design of control circuits (in German), *Regelungstech.* **4,** 1, 13–18, 1956.

Given a regulating system obeying the differential equation

$$x^{(n)}(t) + A_1 x^{(n-1)}(t) + \ldots + A_{n-1}\dot{x}(t) + A_n x(t) = 0 \quad (*)$$

where the A_i are real and $x(t)$ is the variable to be regulated, the problem of "optimum" choice of the A_i is considered under the following assumptions: (1) all of the A_i can be chosen arbitrarily; (2) the effect of a particular disturbance acting on the system is equivalent to a solution of (*) generated by prescribed initial conditions, and it is assumed that the disturbances are such that each of the initial conditions $x(0)$, $\dot{x}(0)$, ... $x^{(n-1)}(0)$ is equally likely; (3) the goodness of regulation is given by $\int_0^\infty \bar{x}(t)\,dt$, where $\bar{x}(t)$ is a solution of (*) due to initial conditions as assumed under (2), in addition, $\bar{x}(t)$ must not be very oscillatory. Author further argues that the cost of the system is a function of the factor A_n ($\cong$ loop gain) but not of the other parameters. With this additional assumption, it follows from elementary algebra that (i) all the eigenvalues of (*) should have the same real part; (ii) the damping ratio ζ should be $0.7 < \zeta \leq 1$, the case $\zeta = 1$ being of special interest to the author.

Reviewer points out that in the extensive literature of the problem [e.g., R. C. Oldenbourg and H. Sartorius, *Trans. ASME* **76,** 1265–1280, 1954; AMR **8,** Rev. 570; D. Graham and L. C. Lathrop, *Trans. AIEE,* **72,** 273–288, 1953, etc.] the above assumptions are regarded as much too naive. Assumption (3) leads to unnecessarily sluggish response. Recalling that (*) is the combined equation of the process and the regulator, it follows that the coefficients of (*) will be constrained by the process parameters which are usually unchangeable, invalidating (1); moreover, process disturbances do not effect those initial conditions which correspond to energy storage within the controller, invalidating (2). Reviewer considers paper superficial. R. E. Kalman, USA

2099. Letov, A. N., Stability of unsteady motion of regulating systems (in Russian), *Prikl. Mat. Mekh.* **19,** 3, 257–264, 1955.

A regulating system governed by the equations

$$\dot{\eta}_k = \Sigma C_{k\alpha} + \eta_k \xi, \quad \dot{\xi} = f(\sigma), \quad \dot{\sigma} = \Sigma p_\alpha \eta_\alpha - \xi, \quad \alpha, k = 1, \ldots, n$$

is considered. Contrary to the other authors (e.g., Lurie, Malkin, etc.), it is assumed that the parameters $b_{k\alpha}$, n_α are certain functions known in the time interval $0 \leqslant t \leqslant T$. The functions $p_\alpha(t)$, $t \epsilon (0,T)$, must be determined so that the stability of the unsteady motion of the system is absolute.

By means of the transformations one obtains a system of $n + 2$ differential equations, of which the first integral represents one $n + 1$ dimensional ellipsoid in the transformed space. Thus the problem of the stability is reduced to the determination of the necessary conditions that the quadratic function (form) of the new coordinates has positive meaning on the ellipsoid surface. These conditions can be established by means of the Sylvester inequality or by the Hurwitz criterion. An example is presented. D. Rašković, Yugoslavia

2100. Petrov, V. V., and Ulanov, G. M., Theory of a servo system with dry friction in the sensitive element (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **101,** 4, 611–614, 1955.

Article gives nondimensional phase-plane analysis of a closed-loop servo system having dry friction in the sensitive element which measures system output. T. P. Goodman, USA

2101. Magnus, K., On a method for investigating nonlinear oscillations and control systems (in German), *VDI Forschungsheft (B)* **21,** 451, 32 pp., 1955.

Author develops slowly varying amplitude and phase method of investigating solutions of nonlinear differential equations to discuss stability limits of high-order systems, in terms of Hurwitz determinants for the approximate equivalent linear system. Examples discussed are van der Pol's equation, and equations of motion for a gyro-stabilized monorail and for a ship-steering system in which allowance is made for a hysteretic effect in the response to rudder movement.

There follows a determination of the errors introduced by this linearizing procedure—the equivalent of the describing function technique of control engineering—in the determination of the periods of free undamped oscillation for a mass constrained by each of six types of nonlinear restoring force, for all of which an exact solution is obtainable. Finally, in appendix, author tabulates the "in-phase" and "90°-phase" components of the describing function, under the heading of "K-transformation," for a variety of power-law and discontinuous straight-line nonlinearities.

While no reference is made to recent similar work in English, e.g., Greif, H. D., *Trans. AIEE*, part II, **72,** 243–248, 1953, paper provides comprehensive and well-presented exposition of subject.

G. D. S. MacLellan, England

2102. Plishkin, Yu. M., Evaluation of integral quality criteria of nonlinear control systems (in Russian), *Avtomatika i Telemekhanika* **16,** 1, 19–26, 1955.

For automatic control systems governed by linear differential equations with constant coefficients, different methods exist for estimation of the integral quality criteria

$$J_2 = \int_0^\infty x^2\,dt, \quad J_3 = \int_0^\infty V\,dt,$$

where $x(t)$ is the curve of the passing process and $V(x_i)$ the positive definite quadratic form. But for nonlinear systems, effective methods are not known. In this paper, utilizing Lyapunov's functions for any nonlinear system, author gives the estimation of the above criteria for the special cases when the passing process is governed by equations

$$x_t = f_1(x) + ay, \quad y_t = f_2(x) + by \quad \text{or} \quad y_t = bx + f_2(y),$$

where a,b are constants, and $f_1(x)$, or $f_2(y)$, are continuous functions which vanish at $x = 0$, or $y = 0$, and satisfy the conditions that guarantee a unique solution for arbitrary initial values. The same method is applied to the estimation of J_3 for the special system of the differential equations of nth order.

[See also AMR **6,** Revs. 1798, 1805.] D. Rašković, Yugoslavia

2103. Lees, S., Design basis for multiloop positional servomechanisms, ASME Ann. Meet., Chicago, Ill., Nov. 1955. Pap. 55-A-126, 19 pp. + 20 figs., 4 tables.

Author treats the design of positional servomechanisms to meet desired specifications. Performance equations and frequency response curves are given for the various types of servomechanisms treated. A design basis for positive servomechanisms is developed by studying the torques involved. R. Oldenburger, USA

2104. Shearer, J. L., Study of pneumatic processes in the continuous control of motion with compressed air-I, *Trans. ASME* **78,** 2, 233–242, Feb. 1956.

Paper presents a study of a servo-motor consisting of a four-way control valve and a double-acting ram with special emphasis on the dynamic behavior of fluid in ram chambers and on the pressure-flow characteristics of the control valve. The theoretical results are compared with the experimental results from a simple control valve and tank and good correlation is obtained.

The mathematics is relatively simple. Nonlinear relations are linearized by considering small changes from initial steady-state values.

Reviewer feels author has made a significant contribution to design of pneumatic components for servo-systems, particularly in stressing the differences between hydraulic and pneumatic components. For example, the effect of side leakage in a pneumatic valve is much more significant than in a hydraulic valve. W. A. Wolfe, Canada

2105. Shearer, J. L., Study of pneumatic processes in the continuous control of motion with compressed air-II, *Trans. ASME* **78,** 2, 243–249, Feb. 1956.

Paper continues the investigation of the previous paper [see preceding review] to a more complicated system composed of valve, ram, and mass load. The system is analyzed for response to small changes in valve opening and to changes of external load. The action of the system is studied by an electrical analog.

The results indicate that the system could be stablized by addition of a suitably sized tank and flow resistance to each end of the ram.

Design charts are included for the solution of the third-order system characteristic equations. W. A. Wolfe, Canada

2106. Plymale, B. T., and Goodstein, R., Nutation of a free gyro subjected to an impulse, *J. appl. Mech.* **22,** 3, 365–366, Sept. 1955.

It is the purpose of this paper to call attention to a particular gyro motion which has been observed and studied in the laboratories of the Boeing Airplane Company. The phenomenon is of extreme practical importance for all instruments which use a gyro as a space-stable element, and no published usable information has been found concerning it. A description and explanation of the motion is presented. An appendix contains the basic equations for the system and the results of approximate solutions. From authors' summary by H. Bilharz, Germany

Vibrations, Balancing

(See also Revs. 2097, 2101, 2125, 2161, 2182, 2236, 2311)

2107. Blehman, I. I., On the problem of stability of periodic solutions of quasilinear systems with many degrees of freedom (in Russian), *Dokladi Akad. Nauk SSSR* (*N. S.*) **104**, 809–812, 1955.

The problem discussed is the stability for small μ of the periodic solutions of

$$\dot{x} = Ax + f(t) + \mu F(x, \mu, t) \qquad [1]$$

where x, f, F are n-vectors and A is a constant matrix. Moreover, F is analytic and f, F have uniformly convergent Fourier series (period 2π) in a certain domain G where F is analytic. Furthermore, it is assumed that for $\mu = 0$ there is a periodic solution. The proof of existence, uniqueness, and asymptotic stability of the periodic solutions for μ small, follows a standard pattern.

Reviewer's observation: Author does not seem to be aware of the important and closely related paper by Coddington and Levinson: *Ann. Math. Statist.* no. 29, 19–36, 1952. [Other references are Blechman, *Inzh. Sbornik*, **16,** 1953; Malkin, "The methods of Lyapunov and Poincaré in the theory of nonlinear oscillations, 1949 (Russian); Shimanov, *Prik. Mat. Mekh.* **16**, 2, p. 129, 1952.

S. Lefschetz, Mexico

2108. Kononenko, V. O., On nonlinear oscillations in systems with varying parameters (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **105,** 229–232, 1955.

The systems dealt with are reducible to the form $\dot{x}_h = \Sigma q_{hk}(\theta, \tau)x_k + V_h(x_1, x_2, \theta, \tau, \epsilon)$; h, $k = 1, 2$, where ϵ is small, $\tau = \epsilon t$ is a slowly varying time, $\dot{\theta} = \nu(\tau)$ is approximately constant and $q_{hk}(\theta + 2\pi, \tau) = q_{hk}(\theta, \tau)$. One assumes first τ constant and solves the linear system corresponding to $V_1 = V_2 = 0$. In the process, the characteristic exponents are assumed pure complex. To obtain the periodic solutions of the complete system, one applies a method of successive approximations (in powers of ϵ) with elimination of the secular terms at each step (Gylden-Lindstedt process of astronomy). Author observes that the method (strictly asymptotic) is applicable even when $\tau = 0$, i.e., to nonlinear periodic systems.

References: Krylov-Bogolyubov, Introduction to nonlinear mechanics, *Ann. Math. Statist.* no. 11; Mitropolskiĭ, *Prikl. Mat. Mekh.*, **14,** no. 2, 1950; Malkin, ibid. **18,** no. 6, 1954; Mandelstam, complete works (Russian), 2, 1947; Bogolyubov, *Akad. Nauk USSR*, 1945].

S. Lefschetz, Mexico

2109. Bradistilov, G., Motion of a system of three consecutively connected mathematical pendulums in one plane, with periodic motion around the position of stable equilibrium (in Russian), *Prikl. Mat. Mekh.* **19,** 1, 113–118, 1955.

2110. Boley, B. A., Thermally induced vibrations of beams, *J. aero. Sci.* **23,** 2, 179–181(Readers' Forum), Feb. 1956.

The influence of a sudden application of heat to one side of a beam is considered. Several diagrams showing the variation of bending moment and of deflection of the beam as a function of its shape and the thermal diffusivity of its material are presented.

W. Ornstein, USA

2111. McDonald, P. H., Jr., Nonlinear dynamic coupling in a beam vibration, *J. appl. Mech.* **22,** 4, 573–578, Dec. 1955.

Paper deals with vibration of a uniform beam with hinged ends which are restrained. Deflection is represented by sum of normal modes multiplied by generalized coordinates, and energy method is used in formulating the equations of motion which are nonlinear due to axial tension. Assuming a solution in terms of elliptic functions, it is shown that the frequencies of the various modes are functionally related to the initial conditions. Vibration of a beam initiated from rest amplitude corresponding to concentrated load at mid-span is treated.

W. T. Thomson, USA

2112. Callahan, W. R., On the flexural vibrations of circular and elliptical plates, *Quart. appl. Math.* **13,** 4, 371–380, Jan. 1956.

Desired are those of the eight natural boundary conditions for which normal modes of vibration are expressible in product functions. Starting with Mindlin's plate flexure equations including transverse shear and rotary inertia in general orthogonal curvilinear coordinates, author specializes these to polar and elliptical coordinates. Coupling between flexural and shear motions is included; therefore solution is adaptable to moderately high frequency modes (wave length of order of plate thickness). Circular plate solution involves Bessel's equation; elliptical plate involves Mathieu's equation and Mathieu's modified equation.

Analysis shows that the frequency equations for all four clamped and free modes for circular plates are expressible as product solutions. For the elliptical plate only those boundaries independent of bending and twisting moments allow a frequency equation in terms of product solutions. No numerical data are included.

A. Rubio, USA

2113. Herrmann, G., and Mirsky, I., Three-dimensional and shell theory analysis of axially-symmetric motions of cylinders, Columbia University; Dept. civ. Engng. and Engng. Mech. Inst. Air Flight Structures TN no. 1, 29 pp., Apr. 1955.

There are two ways of building up a shell theory. One way is to work upward, starting from membrane theory and adding whatever refinements seem necessary. The other is working downward, starting from an exact solution in three dimensions and introducing simplifying assumptions based on the thinness of the shell. The authors have made a contribution to this second procedure by studying the axisymmetric vibrations of a hollow circular cylinder of infinite length. They give the exact solution and evaluate the frequency equation numerically for a shell with a thickness-to-radius ratio of 1/30. Then the assumption of the conservation of normals is introduced and thus shell equations are obtained which contain all possible refinements. In writing these equations, authors follow Mindlin's idea, replacing the shear modulus G by $\kappa^2 G$ and later choosing κ^2 such that for infinitely short waves the shell equations yield the frequency of the Rayleigh waves. It is hard to see why a shell theory, built on the conservation of normals, should at all be able to yield anything like Rayleigh's surface waves.

Authors simplify their equations gradually, dropping either the shear elasticity or the rotatory inertia or both and, at last, even the bending stiffness. For their particular example it turns out that the frequencies of long waves are well described by the membrane theory, while those of short waves are covered by an improved plane plate theory. There is but a narrow band of wave lengths for which neither of these theories is satisfactory. However, it seems likely that this band may broaden considerably when substantially thinner shells are considered.

W. Flügge, USA

2114. Mindlin, R. D., and Deresiewicz, H., Thickness-shear and flexural vibrations of a circular disk, *J. appl. Phys.* **25,** 10, 1329–1332, Oct. 1954.

One of a series of papers on vibration of plates [AMR **4,** Revs. 2826, 4078; **5,** Rev. 2280; **8,** Rev. 2268]. Curves are given showing resonant frequencies of modes of vibration of circumferential order unity in the neighborhood of the frequency of first thickness-shear mode of an infinite plate versus ratio of diameter to thickness for a free circular plate.

G. Pickett, India

2115. Heiba, A. E., Vibration characteristics of a cantilever plate with swept-back leading edge, *Coll. Aero. Cranfield Rep.* no. 82, 18 pp. + 28 figs., Oct. 1954.

Paper presents results of experimental study of the six lowest natural

frequencies and their associated modes of vibration of sixteen cantilever plates with unswept trailing edges, with swept leading edges, and with various aspect ratios. All plates were of uniform thickness. The modes have been characterized by the number of nodal lines in flexure and torsion. A formula permitting determination of natural frequencies of plates with similar planforms of those tested but with different moduli of elasticity and different thickness is presented. P. A. Libby, USA

2116. **Maggiolo, O. J., and Massera, J. L., Dynamic behavior of the automatic balancing disk for centrifugal pumps** (in Spanish), *Fac. Ing. Montevideo, Pub. Inst. Mat. Estadís.* no. 15, 20 pp., 1954.

The differential equation is developed for the axial movement of the shaft and impellers of a centrifugal pump equipped with a balancing disk functioning by leakage through an axial passage and a radial passage. Only rigid-body displacements are considered, and constant discharge coefficients are assumed for the passages. Solutions to the equation and phase-plane plots are presented, with the conclusion that, even when oscillations occur, the frequency is sufficiently high to result in rapid attainment of equilibrium with small damping coefficients.

G. Murphy, USA

2117. **Kumai, T., Estimation of natural frequencies of torsional vibration of ships,** *Rep. Res. Inst. appl. Mech.* **4,** 13, 1–12, July 1955.

For estimating the natural frequencies of the torsional vibrations of a ship author suggests using the ordinary formula for a beam of constant cross section in which the torsional stiffness factor is calculated as an "effective torsional stiffness" by a formula suggested in 1924 by G. Vedeler. For the factor accounting for the apparent mass, the value 1.325 is suggested. On the basis of these suggestions the torsional frequencies for two ships are calculated for which results of measurements are available. Good agreement is reported. K. Klotter, USA

2118. **Karas, K., Characteristic vibrations of strings with elastically supported ends** (in German), *Öst. Ing.-Arch.* **9,** 4, 352–388, Nov. 1955.

Author sets up the equation of motion for small vibrations of an inhomogeneous string with elastically supported ends, in which he includes a term representing rotational inertia. He then applies several methods for approximating the natural frequencies in the case of particular distributions of the density. H. Deresciewicz, USA

2119. **Brodeau, A., Study of internal friction by systematic elimination of inertia forces** (in French), *Publ. sci. tech. Min. Air France, TN* no. 54, 15 pp., 1955.

Internal friction was studied in a pure gum rubber band 1 m long and 5 mm square by measuring the vertical oscillations of a 420-gm weight suspended at one end. The period was approximately 0.6 sec. The modulus of elasticity of the rubber was 200 gm weight per mm², corresponding to a propagation speed of 40 m/sec for a longitudinal wave.

The time-distance curve of the weight shows points of inflection between successive half-waves, at which points the acceleration is zero and the tension equals the weight. Subtracting the weight from the static tension measured at these positions yields the friction force. The friction force is a function of elongation and of velocity, as well as showing hysteresis.

It is shown that, in practice, the friction force is a function only of the static tension, and typical curves are given. These curves are more complicated than those that would be obtained from simple cases, such as friction proportional to deformation or to speed of deformation. It is concluded that the results cannot be mathematically interpreted.

C. F. Bonilla, USA

2120. **Tsobkallo, S. O., Correlation between elastic aftereffects and damping in vibrations in metals** (in Russian), *Zh. tekh. Fiz.* **24,** 3, 566–575, Mar. 1954.

Specimens in the form of very thin flat springs are tested with author's method for measuring damping in vibrations. Method is presented in some detail. For measuring elastic aftereffects, method developed by Davidenkov is used. For the seven different materials investigated it is observed that logarithmic decrement decreases when amplitude of vibrations increases. This is explained by the influence of elastic aftereffects taking place in process of vibrations. It is shown that there is a relation between damping in vibrations and elastic aftereffects.

F. I. Niordson, Sweden

2121. **Moiseev, N. N., On a problem in the theory of waves on the surface of a bounded volume of liquid** (in Russian), *Prikl. Mat. Mekh.* **19,** 3, 343–347, 1955.

The plane problem of forced and natural oscillations in a body of water partly filling a tank is reduced to the study of an integral equation. The forced vibrations are excited by pressure oscillations at an orifice below the water surface.

The Fredholm integral equation has, as its kernel, Green's function for the region occupied by the water. The inhomogeneous equation (forced oscillations) is always theoretically soluble except for resonant frequencies, given by the eigenvalues of the kernel. The eigenfunctions then give the natural oscillations. If the function transforming the region conformally into a rectangle is known, the integral equation can be reduced to an infinite set of algebraic equations, soluble under the same conditions.

The general method is extended to three dimensions, and to cases of nonuniform forcing pressure distributions.

The paper has theoretical rather than practical emphasis.

A. H. Armstrong, England

2122. **Morrow, C. T., and Muchmore, R. B., Shortcomings of present methods of measuring and simulating vibration environments,** *J. appl. Mech.* **22,** 3, 367–371, Sept. 1955.

Problems in the valid description and simulation in the laboratory of random vibration, such as is encountered in the field use of military equipment, are pointed out, and specific means for analyzing and specifying such vibration offered. Limitations of conventional *g* versus frequency vibration measurement, and of single-frequency sweep testing, are discussed.

The root-mean square of the instantaneous acceleration is selected as a single number for best expressing random vibration severity in any segment of the spectrum, and a function, "mean-square acceleration per cycle", or "mean-square acceleration density" in g^2/cps is developed as a quantity to be plotted against frequency for best describing spectral distribution. Methods for interpreting the wave analyzer indications in these terms are given.

Recommendations are given for laboratory testing by the use of line as well as continuous spectra, and the utility of the proposed criteria is discussed. The mean-square density is stated to be adequate for specifications even if structural resonances are present, unless departure from normality is extreme throughout the spectrum.

C. W. Gadd, USA

2123. **Shafer, S. N., and Plunkett, R., A miniature oscilloscope and vibration pickup for nodal pattern tracing,** *Proc. Soc. exp. Stress Anal.* **13,** 1, 123–128, 1955.

Wave Motion in Solids, Impact

(See also Revs. 2161, 2230)

2124. **Owens, R. H., and Symonds, P. S., Plastic deformations of a free ring under concentrated dynamic loading,** *J. appl. Mech.* **22,** 4, 523–529, Dec. 1955.

A concentrated time-dependent force acts on an unsupported thin ring in its plane along a diameter. The deformations of the ring are determined when the force magnitudes are such that plastic deformations are large compared with elastic strains. By neglecting elastic strains and assuming ideally plastic behavior, approximations to the final deformations of the ring are obtained from the momentum and continuity equations. The analysis is developed for force pulses of arbitrary shape, but results through numerical integration are obtained only in the special case of a rectangular force pulse. From energy considerations, a criterion is derived for conditions when this type of analysis can be expected to provide satisfactory results although elastic strains are neglected. It is shown how results for a rectangular force pulse may be used to obtain fair estimates of the deformations from force pulses of quite different shapes. From authors' summary by Z. Karni, Israel

2125. **Press, F., and Oliver, J., Model study of air-coupled surface waves,** *J. acoust. Soc. Amer.* **27,** 1, 43–46, Jan. 1955.

Flexural waves generated in a thin plate by a spark source are used

to investigate properties of air-coupled surface waves. Both ground shots and air shots are simulated in the model. Effects of source elevation, fetch of air pulse, and cancellation by destructive interference are studied. From authors' summary

2126. Tung, T. P., and Newmark, N. M., Numerical analysis of earthquake response of a tall building, *Bull. seism. Soc. Amer.* **45,** 4, 269-278, Oct. 1955.

Earthquake response of a ten-story building is studied, employing a model of concentrated masses supported with vertical shear beams. Analysis is made with a digital computer on dynamic shear which will be caused in each story of the model when the foundation is subjected to the same acceleration as was recorded in the case of earthquakes. It is found that maximum shears computed for various degrees of damping are more than design shears based on the code recommended by the Joint Committee.

Reviewer considers that dynamical analysis of irregular vibration is more reasonable than that based on statical or stationary cases and expects that actual seismograms will be obtained on higher floors to make comparison with computed results. K. Kasahara, Japan

2127. Burshtein, E., and Solov'ev, L., Ground wave propagation between parallel surfaces (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **101,** 3, 465-468, 1955.

Wave which becomes a homogeneous plane wave when the boundaries (perfect conductors) become two parallel planes is termed a ground wave. Its phase velocity is the velocity of propagation of a phase along the midsurface. Using particular parametric representation of these surfaces, a solution of Maxwell equations is sought for small values of the parameters. An expression for wave number and deviation of a ray from a geodetic curve are derived. W. S. Jardetsky, USA

Elasticity Theory

(See also Revs. 2142, 2162, 2163, 2187, 2194, 2214, 2319)

Book—2128. Colonnetti, G., The equilibrium of deformable bodies [L'equilibre des corps deformables], Paris, Dunod, 1955, xi + 162 pp.

This is a book written primarily from the viewpoint of a structural engineer. The five chapters are entitled: (1) General theory of equilibrium; (2) Plastic deformations; (3) Beams and trusses; (4) New theory of beams and arches; and (5) Preconstraints.

In the first chapter the equations of compatibility are derived. The principle of virtual work is then used to establish in "the most general manner" the equilibrium conditions for a body under the action of a given system of forces. A brief discussion of plastic deformation appears in the second chapter, followed by application of the elementary principles developed to the solution of a practical problem. In chap. 3, trusses are analyzed by energy considerations, and the basic principles of limit design are discussed. Chap. 4 develops the author's "new theory" of beams and arches applied in particular to continuous beams and reinforced concrete. In this method, the plastic deformation is computed by taking the diagram of plastic curvature as the loading and considering the flexural moment produced by a unit load as an influence line for displacement. In chap. 5, prestressing of concrete, the principles involved, and the advantages of construction by this method are discussed in detail. E. A. Ripperger, USA

2129. Broglio, L., Analytic questions pertinent to the stability problems of elastic equilibrium (in Italian), *Acta Pont. Acad. Sci.* **15,** 2, 15-24, 1951.

Author gives formulas for the six components of the strain matrix at any point of a three-dimensional elastic medium under finite displacements. Other simplified formulas are also derived for two-dimensional media. These equations can also be utilized for the elastic stability of composite and light structures. L. Villena, Spain

2130. Girkmann, K., Welded joint of a flat bar subjected to tensile stress with constrained deformation (in German), *Öst. Ing.-Arch.* **9,** 2/3, 118-126, 1955.

A flat bar subjected to tensile stress is connected to a rigid body by means of a butt weld; stress problem is assumed to be plane with the following boundary conditions: normal and tangential stress on the free edges, strain ϵ_x (parallel to the joint) and deflection v_y along the welded section, equal to zero.

In the Airy's function $F = F_0 + F_1 + F_2$, F_0 corresponds to uniform tensile stress; F_1 is the Fourier series adopted by author to analyze stress distribution over the slab of T beams [AMR **7,** Rev. 3538]; F_2 is a Fourier integral which eliminates the shearing stress carried by F_1 on the free edges.

Due to completeness of chosen function system, all the prescribed boundary values may be approached at every point; solution shows only a singularity at the end of the welded section. Well-suited developments are employed to reach numerical values; stress distribution is particularly interesting over a strip next to the joint, width of which is one fourth of that of the bar.

Stress distribution is also analyzed in a flat bar having a transverse weld, under the assumption of different longitudinal modulus and same Poisson coefficient for the structure and seam materials.

D. Gentiloni-Silverj, Italy

2131. Jindra, F., Pure plane bending in nonlinear elasticity (in German), *Ing.-Arch.* **23,** 5, 373-378, 1955.

Author applies a theory of nonlinear elasticity presented by H. Kauderer [title source **17,** 1949; AMR **3,** Rev. 2219] to pure bending of a straight rectangular bar and a circular sector by using Airy's stress function. The numerical calculations carried out indicate that the stress distribution changes considerably, even when the elasticity deviates only slightly from the linearity. K. J. Sundquist, Sweden

2132. Mossakovskii, V. I., On similitude of the first fundamental problem in the plane theory of elasticity for multiply connected domains (in Russian), *Prikl. Mat. Mekh.* **19,** 3, 383-384, 1955.

As is known, in solving the first fundamental problem of plane theory of elasticity for two or multiply connected domains, the state of stress turns out to be independent of elastic constants only in case each contour is acted upon by a self-equilibrating system of forces. In this special case, it is possible to determine the state of stress in a prototype by an experiment with a model. Author suggests a method which removes the above restriction and employs three models.

G. Herrmann, USA

2133. Galin, G. Ya., Surface conditions of strong disturbances for elastic and plastic bodies (in Russian), *Prikl. Mat. Mekh.* **19,** 3, 368-370, 1955.

Author states that, in reality, the conditions of rapid change in materials are formulated and derived from thermodynamic laws; e.g., in deformation of bodies, surface disturbances can be examined as reversible equilibria (for elastic bodies) or as irreversible equilibria (for plastic bodies) by thermodynamic processes. Author uses laws of conservation of mass and momentum to substantiate the conversion of energy from one form into another with the further implication of irreversibility for the process. The physical implication of this energy conversion is that the amount of increase in kinetic energy and work, wasted in deformation, must not be larger than the work of the exterior forces. This is expressed by

$$\frac{(\sigma_n)_1 + (\sigma_n)_2}{2}\,[V_2 - V_1] + \rho_1 W_1\,[\Phi_2 - \Phi_1] \leq 0$$

where ρ is density, V velocity, σ_n stress vector, Φ work of the exterior forces, and W velocity of propagation of the disturbance.

For one-dimensional motion one can state that strong disturbances have the least relation to the stress component of deformation.

Author suggests the works of Kh. A. Rakhmatulen for investigations concerning strong disturbances in the presence of plane, one-dimensional motion of elastic bodies. N. M. Matusewicz, USA

2134. Koshelev, A. I., Existence of a generalized solution for elastic and plastic torsional problems (in Russian), *Doklady Akad. Nauk SSSR (N. S.)* **99,** 3, 357-360, 1954.

The proof of the existence of the stress function for a twisted section bounded by a three times continuously differentiable curve is given for the case when the proportionality function between stress and strain deviators appearing in fundamental differential equation of elastic-plastic torsion satisfies certain conditions.

It appears that Newton's method converges more quickly than the method of successive approximations usually applied in elliptical problems.

The importance of the paper is primarily theoretical, whereby the absence of examples can be explained. K. Julis, Czechoslovakia

2135. **Conrad, O., Torsional stresses in blades due to centrifugal force** (in German), *Maschinenbau Technik* **4**, 4, 193–195, Apr. 1955.

Although the title speaks of "stresses," the paper gives only an approximate method for computing the torsional moment, from which torsional stresses at each section may be computed approximately by Saint Venant's theory of torsion. The explicit assumption involved is that the shape of the blade is such that its mass can be considered as being distributed on a surface which is generated by straight lines joining the root cord and the tip cord, both having equal projection lengths on the axis of the wheel. The implicit assumptions are that the cords are small in comparison with the diameter of the wheel and that Saint Venant's theory of torsion is applicable in determining the torsion stresses of a twisted blade. An example is given for the total moment on a blade whose cross section is formed by cubic parabolas and the stresses at the root which is elliptical in cross section. There are a few obvious typographical errors in the formulas. K. N. Tong, USA

2136. **Sobolev, N. D., and Fridman, Ja. B., Strength of solids having varying mechanical properties** (in Russian), *Zh. tekh. Fiz.* **24**, 3, 479–498, Mar. 1954.

Authors' purpose is to investigate the coordination of distribution of mechanical properties in solids in order to obtain the highest specific strength. Mechanical properties involved are "resistance field" and "stress field"; the former is the ultimate strength based on some accepted theory of failure, the latter is the stress—elastic or plastic—to which the solid is actually subjected; both are expressed in terms of reduced stress. The results appear as "strength efficiency coefficients" θ_π, where $\theta_\pi = \theta_p \cdot \theta_\phi$. θ_p is the coefficient of "equal strength," depending on the relative distribution of "resistance" and "strength." It is equal to 1 when the two coincide. θ_ϕ is the "coefficient of form," depending on the shape of the cross section.

The coefficients are obtained by comparing the maximum allowable moments, torques, etc., with the maximum allowable resistance, using elementary conceptions. These coefficients can be quite useful when aiming at proper utilization of various materials for the manufacturing of stressed parts.

The references are nearly all Russian, and, to the reviewer's knowledge, this approach has not been used anywhere else.

J. Solvey, Australia

2137. **Conway, H. D., Further problems in orthotropic plane stress,** *J. appl. Mech.* **22**, 2, 260–262, June 1955.

This is another in a continuing series, by the author, of orthotropic plane stress problems. A solution is given for the case of an infinite, orthotropic plate containing a circular hole, the plate being subjected at infinity to a uniform tensile stress acting in a direction not parallel to the principal axes of orthotropy. This result is obtained by specializing the more general solution given by A. E. Green [*Phil. Mag.* **34**, 416–20, 1943] for the anisotropic plate. A solution is obtained for the case of an infinite, orthotropic plate with an elliptical hole subjected to tension in the major axis direction by generalizing the circular hole solution. The method of solution is indicated for the most general case of the elliptical hole plate but, due to their complexity, the results are not given. J. H. Baltrukonis, USA

2138. **Müller, W., and Krettner, J., Bending theory of a uniformly loaded orthotropic or isotropic rectangular plate with different boundary conditions** (in German), *Öst. Ing.-Arch.* **9**, 1, 11–21, 1955.

If two borders $y = 0$, b of a rectangular plate are simply supported, the solution of the deflection problem (as shown, e.g., in Timoshenko's book) can be found through a Fourier series in $\pi y/b$. For 3 cases ($x = 0$, a supported-free, supported-clamped, free-free), the series are explicitly given and deflection and moment curves are drawn. Through a slightly modified interpretation, the same curves hold also for an orthotropic plate. (The latter conclusion, however, is true only in the special case of the twisting stiffness K_{xy} being proportional to $(K_x K_y)^{1/2}$ – K_x, K_y bending stiffnesses, a case which generally does *not* occur; cf. E. Giencke, *Stahlbau* p. 129, 1955.)

K. Marguerre, Germany

2139. **Hieke, M., The indirect determination of the Airy function for discontinuous thermal stresses** (in German), *ZAMM* **35**, 8, 285–294, Aug. 1955.

Stresses due to stepped temperature distribution and consequent discontinuous density changes are investigated. With the help of the Gauss theorem relating volume and surface integrals, it is proved that the stresses caused by the density changes bring about no change in volume in the body as a whole and also, for the conditions specified, the normal stresses parallel to the tangent planes of the discontinuity surface exhibit a constant jump in crossing this surface, whereas all other stress components are continuous.

Special cases treated: Circular cylinder with concentric and eccentric heated parts, and cylinder in which the surface of discontinuity is a plane. G. Sved, Australia

Experimental Stress Analysis

(See also Revs. 2090, 2409)

2140. **Lissner, H. R., and Perry, C. C., Conventional wire strain gage used as a principal stress gage,** *Proc. Soc. exp. Stress Anal.* **13, 1**, 25–34, 1955.

Formulas based on the same principle as the stress gage are derived showing that it is possible to measure a principal stress by means of a single conventional wire strain gage, provided the principal axes are previously known. The two major sources of error of the method are analyzed, angular mounting error of the gage axis and the effect of the transverse gage sensitivity. The error caused by the misalignment of the gage axis depends on the ratio of the principal stresses; regarding the angular mounting error, it amounts to 5% in the case of pure torsion and one degree of mounting error. The error introduced by the transverse sensitivity is nearly independent of Poisson's ratio and varies linearly with the transverse sensitivity in function of the principal stresses ratio. In order to check the theoretical derivations, author performed a series of tests on a steel cylinder subjected to any combination of axial compression and hydrostatical pressure. He states that these tests show the adequacy of the principal stress gage. It is regrettable that author omitted the numerical test values of principal stresses obtained from longitudinal and transverse gages, and those obtained from direct measurement, thus preventing the reader from a more complete judgment of the accuracy obtained.

C. A. Sciammarella, Argentina

2141. **Tatnall, F. G., Field testing techniques using the bonded-wire strain gage,** *ASTM Bull.* no. 199 (part 1), 62–66, July 1954.

2142. **Pestel, E., A new hydrodynamic analogy of the torsion of prismatic rods** (in German), *Ing.-Arch.* **23**, 3, 172–178, 1955.

The differential equation for the function from which the stresses in a twisted prismatical bar can be derived has led to many experimental techniques of analog computers. The use of the analogy with the two-dimensional motion of a fluid in a field provided with uniformly distributed sources has been described for a permanent flow, e.g., in AMR **4**, Rev. 1877.

Author introduces the analogy with the flow of a fluid in a narrow slit of everywhere the same width over a region similar to the shape of the cross section to be studied. By changing the width of the slit, the effect of sources is simulated. The change of the width in time is supposed to be so small that inertia effects can be neglected.

The stress function appears as the excess pressure in the slit and the unit source strength as proportional to the time derivative of the width, divided by its third power.

Analysis of multiply connected cross sections is also given. Author announces the experimental realization of this analogy in the near future. H. J. Schoemaker, Holland

2143. **Landdeck, N. E., A direct method for model analysis,** *Proc. Amer. Soc. civ. Engrs.* **82**, ST 1 (J. Struct. Div.), Pap. 869, 15 pp., Jan. 1956.

A structural model cut from a single flat sheet of plastic, and SR-4

resistance-type strain gages are combined to offer a rapid solution of a statically indeterminate frame problem. The method of experimental stress analysis, which is described, is considered practical for structural design problems involving short heavy members, frame members where there are sudden changes in the depth of beams, or for the design of highly indeterminate structures. From author's summary

2144. Gluvchinskiĭ, E. V., and Korsakevich, N. I., Combined deformation measurement of machines under operating conditions (in Russian), *Vestnik Mash.* **35**, 7, 23-28, July 1955.

Rods, Beams, Cables, Machine Elements

(See also Revs. 2110, 2118, 2135, 2142, 2168, 2199, 2304, 2396)

2145. Kollár, L., Influence of the shrinking and creep of concrete on cracked reinforced-concrete beams (in Hungarian), *Mélyépitéstudományi Szemle* **5**, 11, 499-505, Nov. 1955.

Changes of stress distribution and deflections under the effect of creep and shrinkage are calculated for reinforced-concrete beams with rectangular or T cross section, subjected to bending moment without axial load. It is assumed that the concrete does not support tensile stresses. The obtained equations are rather involved, and, according to this method, a problem can only be solved by trial and error. It is shown that stresses are changed in opposite directions by creep and shrinkage, whereas deflection is increased by both. G. de Kazinczy, Sweden

2146. Dimentberg, F. M., On the stability of elastic shafts of materials in which hysteresis is present (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **16**, 81-86, 1953.

It has been found by theoretical investigations that an elastic shaft centered in a disk or wheel possesses sufficient stability under ideal conditions, i.e., when friction stresses are not considered and the velocity of rotation is not excessive. However, the instability becomes critical under increasing velocity, deformation, and friction. This problem has already been investigated by I. L. Nikolay and I. B. Bargera, with collaboration of N. N. Davidenkov [title source **16**]. However, the determination of internal and viscous friction is not the solution of the problem in every case, and in some cases seems to be very doubtful. It is known that internal friction reduces the amplitudes of free vibration because of the hysteresis of the material which is characterized by absorption of energy in each cycle of "loading and unloading". Paper presents theoretical analysis of these phenomena. J. J. Polivka, USA

2147. Johnson, R. C., How to design high-speed cam mechanisms for optimum cam and follower proportions, *Mach. Design* **28**, 2, 85-89, Jan. 1956.

2148. Mitterlehner, G., The problem of centrifugal clutches (in German), *ZAMM* **35**, 1/2, 72-74, Jan./Feb. 1955.

Plates, Disks, Shells, Membranes

(See also Revs. 2112, 2113, 2114, 2115, 2125, 2130, 2135, 2137, 2166, 2170, 2171, 2172, 2183, 2186, 2193, 2197, 2394)

2149. Campbell, J. D., On the theory of initially tensioned circular membranes subjected to uniform pressure, *Quart. J. Mech. appl. Math.* **9**, 1, 84-93, Mar. 1956.

Author presents a generalization of Hencky's analysis of large displacements of membrane to include arbitrary magnitude of pretensioning. Explicit pressure-stress and deflection-stress relations are obtained for small, moderate, and large pressures that are accurate to within approximately 10% and 5%, respectively. G. W. Housner, USA

2150. Weil, N. A., and Newmark, N. M., Large plastic deformations of circular membranes, *J. appl. Mech.* **22**, 4, 533-538, Dec. 1955.

Bulge tests on annealed copper plates of two thicknesses check theory well almost up to rupture. Theory extends Gleyzal's analysis using Hencky's deformation theory, Mises' flow conditions, and assumes plastic incompressibility. Simple tensile test is used to give so-called "universal stress-strain" relation between the octahedral shear stress and the octahedral shear strain for incorporation in theory. Theory gives two simultaneous integral equations due to integrating equilibrium stress equations with respect to position. These integral equations are solved numerically by finite difference methods. "Instability condition" is derived in which further straining leads to less pressure borne by plate.

Reviewer draws attention to his treatise "Analysis of deformation," volumes I (1954), II (1954), III (in press), where following remarks are amplified. The deformation approach to plasticity is possible only when there is no "strain transfer" as, in fact, here. The relationship between octahedral shear stress and octahedral shear strain is not sufficient to define plastic behavior of a substance generally, as a phenomenological stress-strain parameter is also necessary and then defines an "octahedral-parametric surface." For annealed copper, this stress-strain parameter is almost independent of position on the "universal stress-strain" curve, but this is not true for most metals. Relationships between stress and strain must obey compatibility conditions, but such are not considered by authors.

In conclusion, reviewer feels that good agreement between theory and experiment here is fortuitous due to symmetry of strain field and choice of copper for tests. K. H. Swainger, England

2151. Haringx, J. A., Design of corrugated diaphragms, ASME Ann. Meet., Chicago, Ill., Nov. 1955. Pap. 55-A-112, 18 pp. + 9 figs.

Three previous papers by the author set forth methods of calculating the rigidity of corrugated diaphragms, the stresses in the sheet material, and the nonlinearity of the relation between load and deflection. As a further step, the introduction of a few simplifying restrictions having no fundamental effect on the problem leads to the conception of a chart giving at once the dimensions a diaphragm must have so as to conform to specific requirements. An example is included by way of illustration. From author's summary

2152. Wahl, A. M., Recent research on flat diaphragms and circular plates with particular reference to instrument applications, ASME Ann. Meet., Chicago, Ill., Nov. 1955. Pap. 55-A-116, 10 pp.

A discussion and literature survey of recent theoretical and experimental developments relating to flat plates and diaphragms is given, with particular reference to applications in pressure-measuring instruments. Developments discussed include: Effects of large deflections; initially buckled diaphragms; plates subject to plastic flow; analysis of temperature and acceleration effects in diaphragms for pressure measurement. Some discussion of instruments utilizing flat or nearly flat diaphragms is given and an attempt is made to indicate possible fruitful avenues of future research in the diaphragm field. From author's summary

2153. Berger, H. M., A new approach to the analysis of large deflections of plates, *J. appl. Mech.* **22**, 4, 465-472, Dec. 1955.

Approximate equations based on neglecting the second strain invariant in the strain-energy integral are used for determining deflections and stresses in uniformly loaded circular and rectangular plates. Good agreement is found with exact solutions for both deflection and stress. Necessary calculation is considerably less than that required with the complete equations. Author indicates that no completely satisfactory simple physical interpretation can be given at this time to the effect of simplifying the equations as he has done. Reviewer suggests that the method should be applicable to a wide variety of large deflection plate problems with the possible exception of those where substantial warping of the surface occurs and those where the deflection is a result of buckling under the action of membrane forces. S. Levy, USA

2154. Weil, N. A., and Newmark, N. M., Large deflections of elliptical plates, ASME Ann. Meet., Chicago, Ill., Nov. 1955. Pap. 55-A-2, 6 pp.

A solution is obtained by means of the Ritz method for the "large-deflection" problem of a clamped elliptical plate of constant thickness, subjected to a uniformly distributed load. Two shapes of elliptical plate are treated, in addition to the limiting cases of the circular plate and infinite strip. Center deflections as well as total stresses at the

center and edge decrease as one proceeds from the infinite strip through the elliptical shapes to the circular plate, holding the width of the plates constant. The relation between edge stress at the semiminor axis (maximum stress in the plate) and center deflection is found to be practically independent of the proportions of the elliptical plate. Hence the governing stress may be determined from a single curve for a given load on an elliptical plate of arbitrary dimensions, if the center deflection is known. From authors' summary by A. H. Hausrath, USA

2155. **Klein, B., Buckling of simply supported plates tapered in planform,** ASME Ann. Meet., Chicago, Ill., Nov. 1955. Pap. 55-A-39, 7 pp.

Design curves are presented for determining the elastic buckling loads of simply supported flat plates of isosceles trapezoidal planform and loaded in compression along the parallel edges. Shear loads are assumed to act along the sloping edges so that any ratio of axial loads may act along the parallel edges of the given plate. Isosceles triangular plates are included as a special limiting case, and the range of the values of the various geometric and load parameters presented in the curves is considered large enough to cover practically all conditions of the type treated which are encountered in practice.

From author's summary by B. E. Gatewood, USA

2156. **Frederick, D., On some problems in bending of thick circular plates on an elastic foundation,** ASME Ann. Meet., Chicago, Ill., Nov. 1955. Pap. 55-A-36, 6 pp.

The governing equations and solutions for the nonsymmetrical bending of circular plates resting on an elastic foundation are presented using the theory developed by E. Reissner. Also included are two examples in which numerical comparisons have been made with the predictions of the classical theory. These are (a) the axially symmetric bending of a finite circular plate on an elastic foundation under a partial uniform loading, and (b) the nonsymmetric bending of an infinite plate on an elastic foundation with a rigid circular inclusion.

From author's summary by W. H. Hoppmann, II, USA

2157. **Hopkins, H. G., and Prager, W., Limits of economy of material in plates,** *J. appl. Mech.* **22**, 3, 372-374, Sept. 1955.

Paper is concerned with the limits of economy of material in a simply supported circular plate under a uniformly distributed transverse load. The plate material is supposed to be plastic-rigid and to obey Tresca's yield condition and the associated flow rule. The criterion of failure adopted is that used in limit analysis. It is shown that the plate of uniform thickness has a weight efficiency of about 82%. Stepped plates of segment-wise constant thickness are discussed, and the plate of continuously varying thickness is treated as the limiting case obtained by letting the number of steps go to infinity.

From authors' summary by P. W. Abeles, England

2158. **Kromm, A., Shearing forces at the supported edges of plates** (in German), *ZAMM* **35**, 6/7, 231-242, June/July 1955.

Author's earlier published theory [AMR **7**, Rev. 1056] assumes a sinusoidal distribution over the plate thickness for shearing stresses and normal stresses perpendicular to the middle plane, and yields a stress and deformation state similar to that of usual theory completed by a stress state asymmetrical to the middle plane but causing no deflections. Hence author especially considers the square plate with uniform load simply supported at all edges. Satisfying the twisting moment boundary conditions at the corners only, or at more points of the edges, he gets solutions of various degress of approximation. The numerical calculation gives a triangular distribution of the well-known corner forces of Kirchhoff's theory over a length of about the plate thickness.

W. Mudrak, Austria

2159. **Nasitta, Kh., Design of thin circular plates loaded eccentrically with point forces** (in German), *Ing.-Arch.* **23**, 2. 85-101, 1955.

The exact solution obtained by E. Reissner [*Math. Ann.* **111**, p. 777, 1935] for the bending of a thin circular plate subjected to an eccentric point load is not found suitable for numerical calculations in design. A method is developed by taking approximate values of the bending moments and shearing stresses in a conformal plane which gives an eccentrically symmetrical coordinate system (y, ϕ). The squares and higher powers of the gradient of the transverse displacement w with respect to y, ϕ are neglected. The usual biharmonic solution of the type $w = C_1\rho^2 V_1 + C_2\rho^2 \cos \theta V_2 + C_3 V_3$, where V's are harmonic functions, ρ and θ the polar coordinates, and C's constants, becomes in the new system (y, ϕ), $w = B^{-1}(C_1 r^2 V_1 + C_2 r \cos \phi\, V_2 + C_3 V_3)$, where $B = 1 + r^2 - 2V \cos \phi$. Putting $V = \log r$, $V_2 = V \cos \phi$, $V_3 = r^{-1} \cos \phi$, the solution for a simply supported edge is obtained. The corresponding numerical results are compared with those obtained from Reissner's solution. The agreement between the two is found to be good.

For design, numerical tables are given for the bending moment M_r.

B. R. Seth, India

2160. **Sherman, D. I., Bending of a circular plate partially clamped and partially supported on the circumference** (in Russian), *Doklādi Akad. Nauk SSSR (N.S.)* **101**, 4, 623-626, 1955.

Author presents a formal solution of problem stated in the title by using the Muskhelishvili method and Taylor series expansion.

G. Herrmann, USA

2161. **Bolotin, V. V., Nonlinear problems in the dynamic strength of plates** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk no.* 10, 47-59, Oct. 1954.

Author presents mathematical solution of elastic plates subjected to periodical dynamic forces (vibration), applying basic differential equation derived by Saint Venant for static loads and using modifications introduced by Timoshenko, to whose publications reference is also made. Examples like uniformly and periodically compressed rectangular plates simply supported along two opposite sides perpendicular to direction of compression are analyzed. Also, hysteresis effect is considered. American (Timoshenko) symbols and nomenclature are used in all mathematical derivations. J. J. Polivka, USA

2162. **Sen Gupta, A. M., Stresses in thin aeolotropic disks rotating about normal axes,** *ZAMM* **35**, 9/10, 372-378, Sept./Oct. 1955.

Paper deals with two problems; the first with the stress distribution in a thin orthotropic (not aeolotropic) elliptic plate rotating steadily in its plane about its center. The lines of elastic symmetry in the plate are not coincident with the axis of the elliptic plate, and, in this respect, paper is an extension of work of Stevenson (1943). The greatest and least values of the nonzero stress component at the boundary occur at the extremities of the minor and the major axes of the ellipse.

The second problem concerns the stress distribution in a circular thin composite disk rotating steadily in its plane about its center. Within a given radius the disk is isotropic; outside this radius "cylindrical orthotropic," i.e., the stress strain relations are in polar coordinates $e_{rr} = a_{11}s_{rr} + a_{12}s_{\theta\theta}$, $e_{\theta\theta} = a_{12}s_{rr} + a_{22}s_{\theta\theta}$, $e_{\theta r} = a_{66}s_{\theta r}$.

J. P. Benthem, Holland

2163. **Hoskin, B. C., and Radok, J. R. M., The root section of a swept wing—A problem of plane elasticity,** *J. appl. Mech.* **22**, 3, 337-347, Sept. 1955.

Equations of plane stress are solved for case of a square elastic plate of constant thickness, loaded with a particular distribution of shear stress along two adjacent sides and with concentrated reacting forces at ends of the diagonal about which loading is symmetrical. Two functions of the complex variable are introduced in a manner originally due to Muskhelishvili. Since technique of solution involves conformal transformation of plate into interior of the unit circle using a complex function which is approximated by finite power series, square shape is distorted slightly through rounding off corners. Because of unfamiliarity of method, steps are presented in considerable detail.

It is shown how stress and displacement distributions along two diagonals of plate can be calculated for arbitrary combinations of shear stress loading and reacting forces. Several numerical examples are given. Satisfactory agreement is obtained with photoelastic measurements for particular case of zero shear and equal compressive loads at ends of diagonal.

Author discusses, with example, how solution might be employed approximately in design of triangular cover plates at root section of a 45° sweptback wing having very heavy root rib. H. Ashley, USA

2164. **Lindblad, A., Shape design of present day commercial vessels** (in Swedish), *Trans. Chalmers Univ. Technol.* no. 163, 176 pp., 1955.

2165. **Johnson, E. E., Pressure tank and instrumentation facilities for studying the strength of vessels subjected to external hydrostatic loading,** *Proc. Soc. exp. Stress Anal.* **13**, 1, 129-138, 1955.

Buckling Problems

(See also Rev. 2193)

2166. Anderson, M. S., Compressive crippling of structural sections, *NACA TN* 3553, 31 pp., Jan. 1956.

Author presents an empirical method for determining the crippling strengths of both extruded and formed sections of arbitrary shape and proportion. In this method the crippling load for an integral cross section may be taken as the sum of a set of defined crippling loads for individual elements. Each individual crippling stress can be evaluated in terms of two parameters, (1) width-thickness ratio of the element and (2) material correction parameter which can be calculated from compressive stress-strain curve. Author also develops a simple criterion to calculate the minimum size of flange necessary to maintain nodes at the joint after buckling.

The development of the empirical method is based primarily on tests of aluminum-alloy channel and z-sections. The applicability of the procedure is verified for other section shapes and other materials, for rivet-fabricated sections, and for sections tested at elevated temperature. T. H. H. Pian, USA

2167. Vasarhelyi, D., and Turkalp, I., Lateral buckling of slender reinforced concrete beams, *Trend Engng. Univ. Wash.* **6,** 3, 8–10, July 1954.

2168. Csonka, P., Buckling of stressed bars of heterogeneous materials, *Acta Techn. Hung. Budapest* **9,** 3/4, 391–404, 1954.

Buckling of prestressed prismatic members is considered on the basis of plane cross sections remaining plane after bending. Critical load is found to be the sum of the critical loads of the individual bar elements. Residual stress alone cannot cause buckling since no tensile energy is liberated during bar flexure. Numerical examples are given of critical load calculations for concrete columns with a parabolic strain curve for the concrete. Supplementary graphical method aids physical insight into column action. It is shown that critical load is increased by concrete shrinkage but decreased by prestressing.

R. B. McCalley, Jr., USA

2169. Hammer, E. W., Jr., and Petersen, R. E., Column curves for type 301 stainless steel, *Aero. Engng. Rev.* **14,** 12, 33–39, 48, Dec. 1955.

Authors discuss results of extensive tests on Type 301 stainless-steel columns having hat section. Variables were degree of cold work, thickness of sheet stock, orientation of column axes relative to rolling direction, and slenderness ratio. Comparison is made with Euler equation based on tangent modulus and reduced modulus.

In general, column curves based upon reduced modulus fitted data best for specimens with axes parallel to direction of rolling. Effect is attributed to cold working during forming. Tangent modulus column curves agreed best with data for transverse specimens.

Forming of hat sections increased load capacity based on properties prior to forming, effect being greater for annealed material and shorter columns. Spot welding reduced average modulus of elasticity directly to degree of cold work (hardness).

Information should aid considerably in clarifying column design, both theoretical and experimental. F. J. Mehringer, USA

2170. Chilver, A. H., The local instability of a simple integral panel, *J. roy. aero. Soc.* **59,** 538, 690–693, Oct. 1955.

A short compression panel consisting of flat sheet to which unflanged longitudinal stiffeners are rigidly attached is considered. Earlier work by Yusuff [AMR **9,** Rev. 717] is discussed and two questions raised: (1) Is the theoretical local instability stress smaller than the corresponding torsional instability stress? (2) Is it possible to explain Yusuff's test results on the basis of conventional local instability theory? An approximate analysis using elastic energy methods yields affirmative answers to both questions. It is further found that two insufficiently general implicit assumptions restrict the usefulness of Yusuff's method.

Comparison with approaches such as that of Gatewood and Williams [AMR **5,** Rev. 1353] would have added interest to the paper.

A. D. Topping, USA

2171. Norris, C. B., Compressive buckling design curves for sandwich panels with isotropic facings and orthotropic cores, *For. Prod. Lab. Rep., U. S. Dept. Agric.* no. 1854, 5 pp. + 12 figs., Feb. 1956.

2172. Mushtari, Kh. M., and Sachenkov, A. V., Stability of cylindrical and conical shells of circular cross section subjected to simultaneous action of axial compression and normal external pressure (in Russian), *Prikl. Mat. Mekh.* **18,** 6, 667–674, 1954.

The starting point for solving this problem is differential equations which were developed by the first of the authors for the purpose of investigating the stability of a conical shell under combined compression and torsion. All boundary conditions are taken into consideration. Approximate formulas for the critical value of the normal load of the shell are given. W. Wierzbicki, Poland

2173. Nylander, H., Snap-through load ("Durchschlagslast") of plates (in German), *Öst. Ing.-Arch.* **9,** 2/3, 181–196, 1955.

Author investigates the conditions under which an initially upward deflected plate turns into a downward equilibrium position. The calculation is performed for elastic conditions. Making use of relations between equilibrium and compatibility equations for initially deflected plate and for initially flat plate, respectively, and using also an approximate but rather accurate relation between load and deflection of the initially flat plate at midpoint, author elegantly arrives at simple conditions for the elastic breakdown of the plate. The initial deflection of the plate is assumed to be affine to the additional deflection.

The approximate relation between load and deflection of the initially flat plate contains two coefficients to be determined by means of the exact solution valid for the plate with large deflection. Author gives these coefficients numerically for nine different cases.

E. Steneroth, Sweden

2174. Botman, M., and Besseling, J. F., The effective width in the plastic range of flat plates under compression, *Nat. LuchtLab. Amsterdam Rap.* no. S. 445, 60 pp., Sept. 1954.

Paper reports the results of an experimental investigation to determine the effective width in the plastic range of certain 24S-T clad and unclad simply supported flat plate-stringer combinations. Among the conclusions which the authors reach from these experiments are: (a) The presence of cladding does not influence the effective width in the plastic region. (b) There is excellent agreement between the experimental values of effective width in the plastic range as compared to theoretical values obtained from the elastic range; therefore, the authors suggest, it is possible to predict with good accuracy the maximum load of plates under compression if the stress-strain relation and elastic range theoretical effective width are known.

Authors caution against using these results for materials with a different form of stress-strain curve, without experimental verification. They also suggest further testing with different edge support conditions.

S. F. Borg, USA

Joints and Joining Methods

(See also Rev. 2130)

2175. Ketchum, V., Glued laminated timber construction, ASME Spring Meet., Portland Ore., Mar. 1956. Pap. no. 56—S—15, 22 pp.

Up-to-date information on glued-laminated construction is presented from the fabricator's viewpoint by one of the outstanding experts in the field. Basic background material for development of design stresses is given in detail in order to provide a better understanding of this highly developed specialized type of construction.

Nail-pressure gluing is ruled out as a substandard procedure. On the other hand, such gluing has been practiced successfully in Europe and Canada for a number of years and, in the reviewer's opinion, can be just as successful as clamp-pressure gluing if a proper glue is selected from the many glues on the market. E. G. Stern, USA

2176. Johnson, J. W., Lateral tests on full-scale lumber- and plywood-sheathed roof diaphragms, ASME Spring Meet., Portland, Ore., Mar. 1956. Pap. no. 56—S—16, 21 pp.

Lateral loading tests on twenty full-size wood roof diaphragms indi-

cated the relatively large influence of construction variables on resistance to static loads which were applied to simulate wind, earthquake, and blast forces. Construction variables investigated covered (1) length-to-width ratios; (2) 1/2 and 3/8-in. plywood sheathing versus green and dry, longitudinally and diagonally applied lumber sheathing; (3) nails versus staples, different nailing patterns, supplementary use of corrugated fasteners; (4) bridging versus blocking; (5) boundary-member construction, corner connections, skylight openings.

The paper summarizes the findings presented in ten detailed laboratory reports listed in the bibliography.

Except for certain staples and corrugated fasteners, all fasteners were low-carbon-steel common-wire nails of standard gage. Doubtless, the stiffness of the diaphragms could be influenced beneficially by the use of (1) larger-gage nails which, on the other hand, might cause splitting under certain conditions; (2) bright high-carbon-steel nails which are stiffer than same size common-wire nails; (3) hardened (heat-treated and oil-tempered) high-carbon-steel nails which are the stiffest of all nails generally available. Since bright and hardened high-carbon-steel nails are in mass-production and commercially available at reasonable cost, it appears that our information is incomplete until test data will be available on diaphragms assembled with these considerably more effective nails. E. G. Stern, USA

Structures

(See also Revs. 2124, 2126, 2163, 2166, 2175, 2176, 2188, 2207, 2215, 2225, 2412, 2413)

Book—2177. **Faber, O., Constructional steelwork,** New York, Philosophical Library, Inc., 1955, xxiii + 368 pp. $12.

An explanation is given of the principles underlining the design and construction of steel frame buildings and other examples of steel structures. From elementary beginnings the reader is led up step by step to more complex aspects, such as the design of frames with end restraint and monolithic welded frames, for which the reduced bending moments in the beams and the additional moments in the columns are calculated. Throughout the book, the use of higher mathematics has been purposely avoided. From publisher's abstract

2178. **Wood, R. H., A note on the problem of rapid design of multistorey frames,** *Struct. Engr.* **33,** 7, 223-224, July 1955.

2179. **Morgan, V. A., Analysis of frames with two gables,** *Concr. constr. Engng.* **51,** 2, 265-272, Feb. 1956.

2180. **Klemp, W., A new method for the calculation of grillage** (in German), *Beton u. Stahlbeton.* **51,** 1, 14-19, Jan. 1956.

The new method is applicable to calculation of grillages whose beams are uniformly distributed in both directions. Assumption is made that the beams of the grillages are of uniform cross section along their full length, and all transverse beams have the same cross-sectional area. The advantage of the new method over the known ones is that it enables the consideration of the torsional resistance of the main beams without appreciably more work. It is also applicable to structures, the cooperation of the main beams of which is assured by a load-distributing plate instead of transverse beams. In the latter case, the plate is considered resisting deflection only in one direction, at right angles to the main beams.

The basic principle of the method is due to J. C. DeFigueiredo Fereaz. It consists essentially of the decomposition of the functions expressing the loading of the main beams into Fourier members and in the solution of the problem for each member separately. If the structure is loaded by concentrated forces at the joints, as many Fourier members are applied as there are intermediate transverse beams. For the individual Fourier members the stress and strain characteristics of the structure are expressible by simple trigonometric formulas. If the number of main beams is four as a maximum, simple closed formulas are obtained for the forces of restraint as well.

The treatise is completed by two numerical examples. From these is apparent the lucidity, simplicity, and practicability of the new method, which thus deserves special appreciation in structural engineering practice. P. Csonka, Hungary

2181. **Beer, H., and Reisinger, F., Exact calculation of stringer and floorbeams for oblique bridges, with help of influence-line method** (in German), *Bauingenieur* **30,** 12, 425-431, Dec. 1955.

Authors give a precise stress analysis for the stringers and floorbeams of skew bridges. It is a further development of the theory given by F. Leonhardt ["Anleitung für die Trägerrostberechnung," 1940] and H. Homberg ["Kreuzwerke," 1951] with consideration of the stiffness of the deck.

Also both mentioned authors have considered the skew nets of girder and floorbeams; they did not give a precise solution, but have recommended a substitute net with girders and floorbeams at right angle to each other. Authors prove by using the influence lines, obtained by their method, that the substitute net always causes smaller moments, (up to 23% smaller for edge girders) than the true system. Numerical examples for computation of bending and torsional moments and shears are given. J. B. Gabrys, USA

2182. **Denke, P. H., A matric method of structural analysis,** *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 445-451.

Matric formulations of the equilibrium equations, the Maxwell-Mohr equations of continuity, the λ-equation of free vibration, and certain "linking equations" are derived for statically determinate and indeterminate structures. The matric Maxwell-Mohr equations account for the effects of thermal stress, creep, initial distortion, residual distortion, and settlement of the supports. The combined equations provide a complete matric formulation which greatly facilitates preparing and coding data for the automatic digital computer.

From author's summary by A.-T. Yu, USA

2183. **Evans, R. H., Circumferential stresses in prestressed pipes,** *Proc. Instn. civ. Engrs.* **4,** (III) 3, 776-783, Dec. 1955.

In deriving a series of expressions to predict circumferential stresses, author implies several assumptions: (1) The wall of the pipe is thin in comparison with its diameter that the membrane theory applies; (2) the materials remain elastic under pressure; (3) there is no slip either between concrete and prestressing wires or between concrete core and steel cylinder. Shrinkage and creep effects are accounted for by separate correction terms. Reviewer believes that the formulas would be helpful to designers, as they can be transformed into design charts.

D. H. Cheng, USA

2184. **Shmakov, M. I., Utilization of gravel soils in earth dams** (in Russian), *Gidrotekh. Stroit.* **23,** 3, 10-12, 1954.

For four large dams consisting of gravel materials, the grain size, bulk density, and permeability data are given. The influence of the grain-size distribution on the density, shearing strength, and permeability is discussed.

The best density was obtained with material containing 35-45% particles 20/80 mm and 20-30% particles < 2 mm. A content of 20% clayey silt doesn't diminish the shearing strength of gravel, while an addition of 50% reduces it to the strength of the added fine-grained soil. An addition of 5% silt and 5% clay reduces the permeability of the sand to a 5 to 10 times lower value. The permeability of the compacted dam material is rather greater than the permeability in situ of the same soil.

L. Šuklje, Yugoslavia

2185. **Nelson-Skorniakov, F. B., Filtration through a drained earth dam on pervious foundation** (in Russian), *Gidrotekh. Stroit.* **24,** 3, 35-39, 1955.

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 2120, 2124, 2128, 2133, 2134, 2145, 2157, 2174, 2211, 2233, 2319, 2338)

2186. **Hodge, P. G., Jr., The theory of piecewise linear isotropic plasticity,** *Poly. Inst. Brooklyn, Aero. Lab. Rep. no.* 328, 50 pp., + 20 figs., Sept. 1955.

Paper summarizes previous work of author and others. "Piecewise linear" denotes two things. First, the tensile stress-strain curve is supposed to consist of two straight lines; the second line need not have zero slope. Second, the yield surface in stress space is a polyhedron, e.g., the hexagonal prism of the Tresca maximum shear stress yield condition. Plastic potential flow law then requires strain-rate vector normal to yield polyhedron, a uniquely determined direction except at corners. Theory is illustrated by solutions for thin-walled circular cylinder under uniform external pressure with various end support conditions for elastic-plastic and rigid-plastic materials with and without hardening. Author also considers limit analysis, minimum principles, and dynamic problem of sudden load application.

Even with Tresca yield condition, the derived yield curve for the significant shell stress resultants is not piecewise linear. It can be approximated by a hexagon, but for simplicity in illustrating theory author approximates it by a square. Reviewer notes that this approximation is equivalent to beginning with maximum normal stress yield condition.

Reviewer also notes that the lettering of author's fig. 7 does not agree with the text. Points ABCD should be at corners of the square (clockwise beginning at lower left), while E,H should replace D,S on the figure.

L. Malvern, USA

2187. Sokolovskii, V. V., Equations in the theory of plasticity (in Russian), *Prikl. Mat. Mekh.* **19**, 1, 41–54, 1955.

Paper is devoted to the formulation of the basic relationships between components of stress and the deformation velocity under conditions of plasticity, in the general sense, without considering any incompressibility of material A detailed study shows the relationships of plane plastic equilibrium as well as the variety of approaches for their transformation. The derivation of these equations in the form of a trigonometric series is given in a relatively simple way. Several forms of the plasticity conditions under which the relationships for plane plastic equilibrium have common coefficients are also examined. The relationships studied are as follows: (1) Basic equations; (2) equations of plane equilibrium of the hyperbolic type; (3) transformation of equations of the hyperbolic and elliptic types; (4) derivation of equations in form of trigonometric series.

N. M. Matusewicz, USA

2188. Il'yushin, A. A., Modern problems in the theory of plasticity (in Russian), *Vestnik Moscov. Univ.* no. 4–5, 101–113, Apr.–May 1955.

This is a nonmathematical review of the contributions to plasticity theory from research workers of Moscow State University on the occasion of its 200th anniversary. Author is the foremost plastician of the USSR. He splits up his subject into seven sections: (1) Theoretical and experimental foundations of plasticity; (2) Theory of small elastoplastic deformations (being the main part); (3) Theory of fully developed plastic flow; (4) Creep of metals; (5) Strength and aftereffects of building materials and concrete; (6) Soil mechanics; (7) Certain new problems. Review covers 45 references, most of them from the past ten years. There is no indication of the contents of the individual papers or even as to their belonging to any of the seven sections.

F. K. G. Odqvist, Sweden

2189. Shield, R. T., On the plastic flow of metals under conditions of axial symmetry, *Proc. roy. Soc. Lond. (A)* **233**, 1193, 267–287, Dec. 1955.

Paper considers flow of a plastic-rigid material governed by Tresca yield criterion and associated flow rule. Types of flow associated with the sides and edges of the yield surface are examined. It is concluded that flow of the Haar-von Kármán type with two principal stresses equal is likely to be important. Specific examples considered are compressive deformation of a circular cylinder and indentation of a semi-infinite slab by a circular flat-ended punch.

Reviewer believes this to be an interesting and important contribution to a topic in which little progress has been made. Plastic potentials and yield criteria having singular points lack physical reality for polycrystalline materials. Nevertheless, results obtained using these idealized concepts will have a certain range of validity which must be the subject of further work.

J. F. W. Bishop, Scotland

2190. Sattler, K., Considerations on the stress-strain law for metallic materials in the plastic region (in German), *Öst. Bauzeitschr.* **10**, 12, 237–243, Dec. 1955.

It is shown how the stress-strain curves of an arbitrary state of stress in the elastic and in the plastic range of some metallic material can be obtained by means of the stress-strain curve of a suitably chosen equivalent uniaxial stressing. Both isotropic and anisotropic media are considered, and a number of examples are treated. These examples demonstrate that the same material shows completely different forms of fracture, depending on the imposed state of stress. Paper furnishes an interesting contribution to the theory of strain-hardening materials.

F. Chmelka, Austria

2191. Eyring, H., and Ree, T., A generalized theory of plasticity involving the virial theorem, *Proc. nat. Acad. Sci. Wash.* **41**, 3, 118–122, Mar. 1955.

A generalization of "absolute reaction rate theory" is made to cases in which the mean energy available to certain degrees of freedom is not kT. Application is made to theory of viscous flow, where an area $\lambda_2\lambda_3$ slips a distance λ under the influence of applied stress f_0. The virial theorem is proved in the usual form $\overline{Xx} + \overline{m\dot{x}^2} = 0$. Authors state "the following identifications can be made: $X = f_0\lambda_2\lambda_3$ and $x = g\lambda$, where g is the ratio of the length of free vibration x of the flowing patch whose area is $\lambda_2\lambda_3$ to the distance jumped λ. Thus g should approximate to the ratio of sound velocity in the solid to that in the gas—a value in the neighborhood of 7." It is not stated whether the gas is composed of molecules or of flowing patches; it appears from the subsequent discussion that g should be replaced by $1/g$ in the last sentence quoted. Using the tacit (and unplausible) assumption that g is independent of temperature, authors explain the empirical observation that the argument of the sinh function in creep formulas is independent of temperature.

Reviewer regards the quoted identifications of X and x as somewhat less than compelling.

F. R. N. Nabarro, South Africa

2192. Gol'denblat, I. I., Theory of small elastro-plastic deformations of anisotropic media (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* 101, 4, 619–622, 1955.

The mathematics are based on the use of an orthogonal rectangular system of coordinates where σ_{ik} and ϵ_{ik} are the stress and deformation tensors, respectively. The equations describing the system of small elasto-plastic deformations of anisotropic media are given.

It is shown that the tensor components of the modulus of elasticity, E_{ikrs}, in linearly elastic media can be expressed in terms of the tensor components of anisotropy, A_{ikrs}. On this basis, the tensor components of anisotropy serve to establish the relationship between stress and deformation. Furthermore, the tensor A_{ikrs} has the same symmetry characteristics as the tensor E_{ikrs}. But in a plastic region, the tensor A_{ikrs} has no relation to the tensor of the elastic modulus E_{ikrs}.

Reviewer believes that the practical validity of this paper is questionable on the basis of the somewhat naive choice of idealized conditions which are so difficult to duplicate in reality. The mathematical validity of the paper is unquestioned.

N. M. Matusewicz, USA

2193. Yamamoto, Y., A general theory of plastic buckling of plate, *Inter. Shipbldg. Progr.* **2**, 14, 458–462, 1955.

Author discusses in general the processes which occur in a plate loaded plastically in its plane prior to and during the buckling of the plate. Initial imperfections are considered. Plate is assumed to be loaded in such a way that, in the first stages, Shanley-type deformation with no unloading takes place (tangent modulus). At a certain stage of development of Shanley state, plate is assumed to acquire zones of unloading on convex side, with resulting change in behavior from Shanley-type to Karman-type buckling (reduced modulus). In Karman state, plate becomes stiffer than in Shanley state, and hence load to produce buckling failure must be larger. Actual failure is assumed to occur in Karman state. By means of variational theorems, greatest lower bound of Shanley state and sub-greatest lower bound of Karman state are obtained for simply supported rectangular plate loaded in uniform compression along only two edges, Results of tests in each case show compressive loads in excess of the theoretical greatest lower bounds. Theory is general enough to include other loading conditions and plate shapes.

H. J. Plass, USA

2194. Zhukov, A. M., Poisson's ratio in the plastic range (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 12, 86–91, Dec. 1954.

2195. **Jain, M. K., The motion of an infinite cylinder in rotating non-Newtonian liquid,** *ZAMM* **35,** 9/10, 379–381, Sept./Oct. 1955.

It is shown that Dean's result on the motion of a cylinder in an uniformly rotating mass of viscous fluid [AMR **8,** Rev. 3103] remains valid when the fluid has the property of cross viscosity.

L. J. F. Broer, Holland

2196. **Weltmann, R. N., Friction factors for flow of non-Newtonian materials in pipelines,** *Indust. Engng. Chem.* **48,** 3 (part I), 386–387, Mar. 1956.

Failure, Mechanics of Solid State

(See also Revs. 2212, 2217, 2218, 2219, 2234, 2408)

2197. **Anderson, R. A., and Anderson, M. S., Correlation of crippling strength of plate structures with material properties,** *NACA TN* 3600, 50 pp., Jan. 1956.

A correlation approach to the crippling-strength analysis of plate structures in new materials and at elevated temperatures is presented. Appropriately defined crippling-strength moduli and correlation procedures are given for predicting the effect of a change in material properties on the strength of a structure. The strength moduli are readily calculated from the effective compressive stress-strain curve for the structural material. The correlation procedures are applicable to multiplate-element components and the accuracy is illustrated with available experimental data obtained in various materials and under different temperature conditions. From authors' summary by G. Gerard, USA

2198. **Broberg, K. B., Studies on scabbing of solids under explosive attack,** *J. appl. Mech.* **22,** 3, 317–323, Sept. 1955.

Author presents a theoretical discussion of scabbing, i.e., fracturing that occurs when an intense shock wave in a solid is reflected from a free surface. He gives considerable numerical data on pressures, constants of equations of state of materials, etc., that can be applied to specific metal-explosive systems. Results of his experiments do not agree well with his theory. Author has probably chosen experimental conditions for which the theory does not apply. J. S. Rinehart, USA

2199. **Kugel', R. V., Fatigue resistance calculations and dynamic loads in transmissions** (in Russian), *Vestnik Mash.* no. 8, 7–12, Aug. 1955.

Paper deals with effect of gear changes and acceleration on life of automobile transmissions. Analysis of German [Glaubitz, *ATZ* 1948] and Russian tests shows that transmission components can be subjected to torques of 1.4 to 2.8 of maximum equivalent engine torque *M* for about 1 to 2 revolutions of the output shaft. Operation of 4 to 7-ton lorries in Moscow requires 310 to 340 gear changes in the three lower gears per 100 km as compared with 10, 18, and 133 on good, poor, and very poor country roads, respectively. Author suggests that transmission components should be endurance-tested under conditions: (1) When starting an changing gears; (2) accelerating in first and second gear; (3) moving on heavy going; (4) load in high gears; (5) load due to poor driving, i.e., braking without declutching and jerking out of ditches; (6) overrunning. Suggested test torques for 5 to 5.5-ton lorries: (1) 0.7 *M* for 1 revolution of transmission output shaft; (2) 0.3 *M*, 3 sec. in each gear; (3) 0.5 to 0.8 *M* in first, 0.4 to 0.5 *M* in second gear; (4) 1.5 to 2 *M* and 2.5 to 3 *M* for vehicles in excess of 5.5 tons.

In view of incidence of failures of transmission components designed to deal with torques in excess of maximum engine torque *M*, the paper is timely and thought provoking. Reviewer considers that reasons for appearance of high torque values merit further investigations. The axial inertia of suddenly engaged clutch plates appears to be responsible for transmitting peak torque in excess of static maximum clutch torque, this resulting from rotational inertia of flywheel, etc.

J. L. Koffman, England

2200. **Jaffe, L. D., Temper brittleness of pressure vessel steels,** *Welding J.* **34,** 3, 141-s—150-s, Mar. 1955.

Paper is comprehensive review of present state of knowledge and contains 177 references to literature. Temper brittleness of carbon and low-alloy steels after tempering between 700 F and formation temperature of austenite is manifest as increase in transition temperature of notch impact test. Fracture predominantly intercrystalline and grain-boundary resistance to picric acid in water or ether etch is reduced. There is also a decrease in lattice parameter of ferrite phase. Various heating cycles resulting in temper brittleness are stated; complete removal of temper brittleness is accomplished by heating above austenitic transformation temperature. Addition of molybdenum up to 0.6 % increases time of exposure necessary for embrittlement. Increase of chromium or manganese increases transition temperature for given treatment. Effect of other elements—carbon, vanadium, phosphorus, nitrogen, arsenic, titanium, cobalt, tin, lead, copper, etc.—are also stated. Antimony is particularly important if 0.08% present. Greater susceptibility is noted in steels tempered from fully hardened martensitic structure than when incompletely (banitic) hardened. Conditions for temper brittleness are favorable in multipass welding and stress relieving. This is important for pressure vessels where temper brittleness may develop in service at temperatures over 800 F for chromium, manganese, and nickel steels. No failure of pressure vessels due to temper brittleness is reported. Theories of temper brittleness, proposals for investigational work, and measures for prevention and cure are discussed.

R. Weck, England

2201. **Davidenkov, N. N., and Stavrogin, A. N., Strength criteria in brittle failure and in two-dimensional stresses** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 8, 101–109, Aug. 1954.

Fracture tests of thin-walled tubes of glass and gypsum by means of an internal pressure with the simultaneous application of an axial tensile or compressive stress and maintenance of proportional loading conditions show that the largest normal tensile stress [the first (maximum normal stress) hypothesis of strength] and not the largest elongation or the largest shear stress is the strength criterion for the two-dimensional stress state.

This condition persists until the ratio of the main compressive force to the main tensile force equals 7.5 for glass and 2.7 for gypsum.

Upon further increase of this ratio, the second (maximum strain) hypothesis of strength gradually loses its force. For glass the transition portion remains unobserved. For gypsum in this portion there can be assumed an octahedral (shear stress) hypothesis with a correction (according to Miroliubov) for the influence of the normal stress.

A statistical treatment of the results obtained for glass show their complete verification in the majority of cases.

From authors' summary by A. M. Turkalo, USA

2202. **Ripling, E. J., Strain aging behavior of rheotropically embrittled steel,** *Trans. Amer. Soc. Metals* **46,** 184–196, 1954.

The rheotropic recovery produced in a steel heat-treated to a high hardness level is shown to persist through a second tempering (or aging) treatment up to temperatures at least as high as the initial tempering temperature.

The rate at which the ductility of rheotropically recovered metal is lost at low aging temperatures and recovered again at higher temperatures is far in excess of that found in the same metal under conditions in which the recovery is not necessary. From author's summary

2203. **Zaslavski, Yu. S., Shor, G. I., and Lebedeva, F. B., Precision in engine wear investigations achieved by radioactive tracers** (in Russian), *Izv. Akad. Nauk. SSSR Otd. tekh. Nauk* no. 1, 54–60, Jan. 1954.

See AMR **9,** Rev. 1828.

2204. **D'iachenko, P. E., and Nisnevich, A. I., Use of radioactive tracers for estimating piston ring wear** (in Russian), *Vestnik Mash.* **35,** 7, 19–22, July 1955.

2205. **Vainshtein, V. E., Use of radioactive isotopes in studying the wear of the structural components of bronze** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 5, 114–118, May 1955.

2206. **D'iachenko, P. E., Kestner, O. E., and Chatynian, L. A., Investigation of mechanical wear in dry friction and at elevated temperatures** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 11, 44–52, Nov. 1954.

2207. **Hample, W. G., Friction study of aircraft tire material on concrete,** *NACA TN* 3294, 34 pp., Sept. 1955.

A systematic study was made of the variation of frictional resistance between typical tire-tread material and three concrete surfaces of different roughness at various temperatures and normal pressures. The tire-tread specimens were taken from the thickest portion of worn ten-ply tires, and the three concrete test blocks were poured from the same mix but subjected to different surface finishes. Curves are presented of the apparent coefficient of friction as a function of normal pressure.

From author's summary

2208. Colner, W. H., and Francis, H. T., Influence of exposed area on stress-corrosion cracking of 24S aluminum alloy, *NACA TN* 3292, 22 pp., Nov. 1954.

Results are presented of a study of the "area effect" in 24S aluminum alloy. This effect is the phenomenon whereby small exposed areas show long times to stress-corrosion failure, whereas large areas show short times. The effects of stress level, degree of sensitivity of the alloy, and hydrogen peroxide concentration in the corrosion medium were studied. Hydrogen peroxide decomposition and the substitution of oxygen for peroxide were also investigated.

From authors' summary

Material Test Techniques

(See also Revs. 2216, 2217, 2218, 2230)

2209. Bland, D. R., and Lee, E. H., Calculation of the complex modulus of linear viscoelastic materials from vibrating reed measurements, *J. appl. Phys.* **26**, 12, 1497–1503, Dec. 1955.

Reed-shaped specimens of the material, whose real and complex moduli for oscillatory motion are desired, are excited at the clamped end at a known sinusoidal amplitude. Two methods are derived for obtaining these moduli and their variation with frequency. One is based on relative amplitude and phase lag of the free end of a single specimen, while the other employs peak resonant amplitude of a series of specimens of differing natural frequency.

The general viscoelastic law is employed in order to eliminate error in an earlier method based on a simple viscoelastic law and utilizing measurement of breadth of the resonance curve.

C. W. Gadd, USA

2210. Field, J. E., Tensile stripping tests on B. S. W. ¾ in-10 T. P. I. threads, *Engineer, Lond.* **200**, 5213, 901–902, Dec. 1955.

The object of the tests was to determine the relationship between nut height and static stripping strength of assemblies of ¾ B.S.W. nuts and bolts from steels to Codes A, P, and T, B.S. 1768–1951, in different combinations. Static stripping tests have been carried out on high tensile (EN 16T) steel bolts and nuts, high tensile bolts with mild-steel nuts (to strip the nuts), and low tensile steel (EN 7) bolts with high tensile nuts (to strip the bolts). The effect of end-conditions has also been examined by testing assemblies with and without bolt threads protruding beyond the nut face. The conclusions reached are that the static stripping strength of a bolt and nut assembly is proportional to the height of the nut irrespective of whether the bolt threads or the nut threads are stripped; and that for a given height of nut, the strength of a combination assembled with the nut face flush with the end of the bolt is less by about 10% than that of a combination with one or more threads protruding from the nut. The difference is greater when the nut threads strip.

From author's summary.

2211. Grodzinski, P., Considerations of elastic and plastic hardness (in German), *Kolloid Z.* **139**, 1/2, 11–17, Nov. 1954.

2212. Russenberger, M., and Foldes, G., High-speed universal fatigue testing machine. Verification of statically calibrated mechanical-optical dynamometer, *Proc. Soc. exp. Stress Anal.* **12**, 2, 9–20, 1955.

In order to reduce time needed for fatigue testing, a high-speed fatigue testing machine has been developed. The working principle of the machine and some of its applications are described. The question arose whether it was permissible to use a statically calibrated mechanical-optical dynamometer as a load indicator for dynamic tests. Experiments with the aid of electrical resistance strain gages were carried out which showed that the indications of the dynamometer were correct and that the stress-time curve was practically sineform.

From authors' summary.

2213. Peters, R. W., The NACA combined load testing machine, *Proc. Soc. exp. Stress Anal.* **13**, 1, 181–198, 1955.

A detailed description is given of the design, calibration, and operation of this unique testing machine for providing any combination of tension or compression loads, torsion and bending moments to specimens up to 41 in. in diameter and up to 240 in. in length. Calibration of the machine showed that it indicated loads well within the ±1% tolerance limits set for the usual tension and compression testing machines, for each one of its twelve loads directions over the load ranges of 12,000-lb tension and compression, ±25,000 lb in horizontal shear, ±50,000 lb in vertical shear, ±500,000 in.-lb in torsion, ±600,000 in.-lb in bending in either horizontal or vertical planes. Capacities in compression can be doubled and in torsion can be multiplied five times by limiting the other load components. Unique features of the machine include combination needle-roller bearings to permit the hydraulic load cylinders to rotate through any angle and to translate, and they include annular pistons for the application of moments to the loading head of the machine. Application of the machine is illustrated by tests to determine buckling strength under combined compression and torsion of cylindrical shells and reinforced box beams, as well as bending tests and torsion tests of high strength components of wing beams. The machine has also provided the theory of plasticity with much-needed data on the strength and deformation of metals under combined stresses. Because of its versatility, accuracy, and high capacity under combined loads, the machine has become the testing machine in greatest demand in the Aircraft Structures Laboratory of the NACA.

W. Ramberg, USA

2214. Lubahn, J. D., On the applicability of notch tensile test data to strength criteria in engineering design, ASME Ann. Meet., Chicago, Ill., Nov. 1955. Pap. 55–A–149, 10 pp. + 1 fig.

2215. Muhlhausen, E. K., Loewer, A. C., Jr., and Eney, W. J., Torsion testing equipment for cylindrical cement specimens, *Proc. Soc. exp. Stress Anal.* **11**, 1, 97–104, 1953.

A torsion loader and a torsion strain gage developed for the purpose of determining shear moduli of elasticity of cylindrical plasticized sulfur cement specimens are described. The design of each and the results of their combined application on pilot specimens are presented.

From authors' summary

Mechanical Properties of Specific Materials

(See also Revs. 2120, 2169, 2177, 2200, 2202, 2205, 2208, 2211, 2214, 2419)

Book—2216. Siebel, E., and Ludwig, N., edited by, Testing of metals. Handbook of testing materials, Vol. II [Handbuch der Werkstoffprufung. Die Prufung der metallischen Werkstoffe], 2nd ed. Berlin, Springer-Verlag, 1955, xv + 754 pp. DM 118.50.

In the second edition, the size of the volume has remained unchanged; three chapters (on metallography, chemical and spectroscopic analysis) which occupied one-fifth of the first edition have been omitted, and the length of the remaining ones correspondingly increased. The Introduction (34 pp. on the physics of the metallic state, by U. Dehlinger) and chap. 1 (104 pp. on static tests, by the late F. Körber and by A. Krisch) have received only minor additions; chap. 2 (61 pp. on impact testing, by K. Fink, C. Rohrbach, and R. Mailänder) has been rewritten, as well as chap. 3 (72 pp. on testing under cyclic stress, by H. Sigwart). Chaps. 4 (113 pp. on tests at high and low temperatures, by the late A. Pomp and by K. Bungardt) and 5 (52 pp. on hardness testing, by W. Hengemühle) show only slight additions and alterations. The material of chap. 6 of the first edition, which occupied 54 pages, has been split up into three chapters, the first dealing with "technological tests" (bending, folding, double-folding, notch-folding, cupping, and a host of similar tests), the second with tests on welds, and the third with wire and rope testing (a total of 83 pp., by K. Wellinger, N. Ludwig, and H. Müller). These are followed by chap. 9, a mixed bag dealing with wear, bearing materials, machining, erosion and cavitation, and corrosion (136 pp. by five authors). Chap. 10 (physical measurements, including x-ray structural investigations; 49 pp., by F. Wever) has been taken over from the first edition with few alterations. Chap. 11 (36 pp. on "theoretical investigations on strength and plasticity", by A. Eichinger) is quite

new; much of the material of the corresponding chapter in the first edition has collapsed in the meantime, and it has been replaced by a mathematical analysis of the mechanical behavior of materials, often so highly idealized that a comparison with real materials would seem almost unfair. A typical instance of this is the statement (on p. 721) that, in the case of shear fracture, the greatest shear stress is a material constant. If it were, a ductile metal like copper or low-carbon steel would fracture in compression or in rolling at about the same strain as in tension. An unattractive feature of the chapter is that the Mises-Hencky yield condition, Nádai's octahedral shear stress and strain, and the Lévy-Mises equations are developed on an unconvincing basis of mathematical aesthetics without any reference to the experimental background or to the names of their authors. The Tresca (maximum shear stress) yield condition which governs the yielding of structural steels is not mentioned at all, perhaps because it is outside the formal scheme used for the introduction of the Mises condition.

The characteristic feature of the volume is that most of its chapters are confined to methods of testing in the narrower sense; testing equipment and the physical interpretation of the test results are excluded as far as it is feasible. (Testing machines are described in Vol. I of the Handbuch.) This allows space for a very detailed treatment of test procedures, codes, standards, etc., which makes the volume a unique and invaluable encyclopedia in its field. On the other hand, it is not a book to be read for intellectual satisfaction. The fundamental reactions of metals to stress, such as fatigue, corrosion fatigue, stress corrosion, brittle and ductile fractures, or creep, disappear behind a formal enumeration of test procedures; the reader has the impression of a prodigious Linnaean classification hardly concerned with natural relationships. An instance of how far procedures and their understanding are divorced is the chapter on hardness testing, which is introduced with the statement that the concept of hardness is still in an unsettled state. That the meaning of the indentation hardness of ductile metals was fundamentally elucidated by Prandtl and Hencky more than 30 years ago, hardly more than 100 miles from where the chapter was written, is not mentioned; empirical relationships between hardness on one hand and ultimate strength on the other are discussed in great detail, but the simple fundamental reason for such a relationship is not given. In several other chapters also the reader can admire the grim puritanic determination of the writers not to disclose whether anything is known about the deeper physical meaning of the tests and test results they describe. A laudable exception is H. Nowotny's section on erosion in chap. 9, in which facts, theoretical points of view, and testing methods are discussed highly satisfactorily. In the chapter on testing at high and low temperatures, test equipment is discussed at great length, with beautiful illustrations and a wealth of details about the behavior of individual materials, but with a complete omission of general points of view that may bring order into the chaos of phenomena. Also out of the general line is a section by the late F. Schwerd on machining and chip formation, in which the writer's interesting experiments are discussed in great detail, while theory, testing for machinability, and work done by other authors remain in the background.

The volume will be indispensable in the testing laboratory, but even to the scientist of the solid state it is as interesting as a series of plant visits under the guidance of competent works engineers.

E. Orowan, USA

2217. Hyler, W. S., and Simmons, W. F., Factors influencing the notch fatigue strengthening of N-155 alloy at elevated temperatures, *Trans. ASME* **78,** 2, 339–348, Feb. 1956.

Data are given to illustrate the effect of stress raisers on the elevated-temperature fatigue behavior of N-155 alloy. These data were obtained on specimens notched with V-grooves having various root radii and various notch severities. The experimental program was in direct-stress fatigue, and covered a range of alternating stress to mean stress from $A = 0.0$ to $A = \infty$ at temperatures of 1200 to 1500 F. The effect of surface finish also was studied to a limited extent. A metallographic study of fractured surfaces was carried out. From authors' summary

2218. Carlson, R. L., MacDonald, R. J., and Simmons, W. F., Factors influencing the notch-rupture strength of heat-resistant alloys at elevated temperatures, *Trans. ASME* **78,** 2, 349–358, Feb. 1956.

Stress-rupture tests were conducted on notched and unnotched or plain bars of S-816, Inconel "X" Type 550, and Waspaloy alloys at test temperatures ranging from 1200 to 1600 F. The notched specimens had 50%, 60-deg, V-notches with the root radii ranging from 0.005 to 0.100 in. In some tests, as many as three notches of different root radii were used. The test results indicated that S-816 alloy was notch-strengthened by all of the notches used in the temperature range from 1350 F to 1600 F. Inconel "X" Type 550 was always notch-strengthened by all of the notches only at the test temperature of 1600 F. Waspaloy was always notch-strengthened by all notches only at the temperature of 1500 F. Both Inconel "X" Type 550 and Waspaloy could be notch-strengthened for some test conditions (notch sharpness and time) at temperatures below 1600 and 1500 F, respectively. Factors considered to have an influence on stress-rupture behavior have been studied and the results are included. The factors investigated are notch geometry, notched and unnotched ductility, the modes of deformation and fracture, metallurgical changes, and surface condition. The influence of some of these factors can vary considerably from alloy to alloy. It does not appear possible, therefore, to evaluate completely the notch and unnotched stress-rupture behavior of a given alloy by any simple method. Rather, an evaluation should be based upon the combined consideration of those factors that are influential in each individual case. From authors' summary

2219. Zot'ev, A. I., New thermal and chemico-thermal metal treating methods using fused salts (in Russian), *Vestnik Mash.* **35,** 5, 67–71, May 1955.

2220. Preston, C., Some bearing materials under high pressures at low rotational speeds, *Coll. Aero. Cranfield Note no. 12*, 35 pp. + 14 figs., July 1954.

A series of tests was carried out, in the Design Department of the College of Aeronautics, on plain journal bearings, at higher pressures than are normally encountered in engineering practice. Pressures of 40,000 psi were realized with a rubbing speed of 1.1 ft/min. Comparison between the various materials tested was effected by continuously rotating the bearings for fixed periods under various loads while friction and wear were measured periodically. The most outstanding combination was S.90 chromium-plated running in a Hidurex Special bearing. Some other materials were also found to be suitable, although not so wear-resistant.

All the materials tested suffered some surface damage which, in general, proved not to affect the bearing performance.

An attempt is made to explain the behavior of the bearings and thus indicate possible further materials which might prove suitable.

From author's summary

2221. Norton, J. T., Cermets for high-temperature service, *Mech. Engng., N.Y.* **78,** 4, 319–322, Apr. 1956.

2222. Smoke, E. J., and Koenig, J. H., Ceramics as basic engineering materials, *Mech. Engng., N.Y.* **78,** 4, 315–318, Apr. 1956.

2223. Carp, H., New experiences with water-tight concrete (in German), *Beton u. Stahlbeton.* **50,** 5, 136–139, May 1955.

Book—2224. Anonymous, Wood handbook, U. S. For. Prod. Lab., U. S. Dept. Agric. Handbook no. 72, 528 pp., 1955.

Superseding a previous publication and a slightly revised edition of a 1935 publication of same title, this important handbook gives an authoritative summary of the structure, characteristics, physical and mechanical properties of wood, and their commercial and structural grades. Lumber and timber fastenings, solid and composite (built-up and glued-laminated) structural members as well as plywood, modified wood, fiberboard, sandwich construction, poles, piles, and ties are covered. One section is devoted to wood bending, others to moisture and shrinkage control, fire resistance, wood finishing, and preservation.

References are made to more detailed accounts in literature listed at the ends of all chapters. The references are dated as late as 1953, hence, more recent developments may not be found in this valuable handbook.

E. G. Stern, USA

Book—2225. Knuchel, H., Wood [Das Holz], Frankfurt am Main, Germany, H. R. Sauerlaender & Co., 1954, 472 pp. $6.50.

Divided into three distinct parts, this well-illustrated (254 photographs and drawings) handbook presents precise information on: (1) The structure and the physical and mechanical properties of wood, as well as their influences on its utilization; (2) the structural and chemical uses of wood and its improvement by mechanical and chemical means;

(3) the various kinds of wood originating in Europe, North America, Central and South America, Africa, Asia, and Australia and New Zealand.

The excellent illustrations covering the structure and defects of wood are valuable visual aids to the novice in the field.

The encyclopedic third part on the woods from all parts of the world provides a detailed survey on their origin, growth characteristics, appearance, and utilization. It is for this part that the book should and will be of particular value to the wood technologist, importer, dealer, and user. E. G. Stern, USA

2226. Stamm, A. J., and Seborg, R. M., Forest Products Laboratory resin-treated wood (impreg), *For. Prod. Lab. Rep., U. S. Dept. Agric.* no. 1380, 10 pp. + 2 tables.

2227. Farrow, B., Extensometric and elastic properties of textile fibres, *J. Text. Inst., Trans.* **47,** 2, T58–T101, Feb. 1956.

Load extension and elastic recovery results are given for some sixty fiber samples tested under three conditions—air dry, immersed in cold water, and immersed in hot water. Fifteen chemical classes of man-made fiber are represented, with some natural fibers for comparison. The effect of a pretreatment in hot water on the tensile behavior of the fibers in air is also examined. Some of the synthetic-polymer fibers contract greatly on treatment and their extensometric properties are much modified. Wetting tends to eliminate the initial, high-modulus region of the load-extension curve, and temperature rise may cause a similar change. In general, these two factors also affect elastic recovery in the same way, bringing about an increase of recovery from imposed strain. From author's summary

2228. Alexander, E., Lewin, M., and Shiloh, M., Measurements of friction between single fibres before and after an oxidative treatment, *Bull. Res. Counc. Israel* **5C,** 1, 28–34, Dec. 1955.

In the course of an investigation on the oxidation of wool fibers, it was necessary to determine the influence of such treatments on the surface structure of the fibers. The coefficients of friction of wool fibers and human hair were measured before and after treatment with bromate solutions.

The method of measurement consists in detecting the slide movement of two twisted fibers which are stretched under different constant loads. This movement, or disturbance of the equilibrium state, happens when the number of twist turns is decreased to a critical value where the coefficient of friction can be calculated.

All the friction coefficients increase after the treatment, but no significant change was found in the directional-frictional-effect.

It seems that in order to get better reproducibility of similar measurements it is necessary to take crimp of wool fibers into consideration. From authors' summary

2229. Erickson, E. C. O., and Norris, C. B., Tensile properties of glass-fabric laminates with laminations oriented in any way, *For. Prod. Lab. Rep., U. S. Dept. Agric.* no. 1853, 31 pp. + 11 tables, 25 figs., Nov. 1955.

A mathematical analysis of the properties of laminated fabrics in the plane of lamination is given, assuming the individual plies to obey the generalized Hooke's law and to possess orthotropy (two axes of symmetry). Modulus of elasticity, Poisson's ratio, and strength are predicted for various axes and several laminates from the properties of the individual plies, and tests are performed to verify the theory. Three laminated glass-cloth panels with warp directions of individual plies oriented at various angles with respect to the other plies were prepared, and strips cut out at various angles for testing. The tensile stress-strain diagrams exhibit a knee, and both primary and secondary moduli were predicted. Agreement between theory and experiment was good for the most part only for the initial modulus. In unloading and reloading, agreement was "reasonable," i.e., mediocre. Measured lateral strains agreed well only in the initial phase. Computed strength values were generally conservative.

Paper presents the results of a needed study carefully done, and is an important contribution to the mechanics of laminated fabrics. The authors, however, make no attempt to explain the disagreements between theory and experiment. In view of their statement in the mathematical development that all their equations before the assumption of orthotropy "apply to all materials," although they involve Hooke's law, reviewer would like to point out that laminated fabrics are not homogeneous. Each ply consists of a woven lattice embedded in a matrix of weak though rigid resin. The deformation of a lattice is, in general, non-Hookean. If the knee in the stress-strain curve corresponds to cracking of the resin, it seems probable that the poor agreement between test and theory in subsequent phases of loading is due to nonlinear deformation of the woven lattice. With flexible resin or neoprene matrix, this effect would be more marked. A. D. Topping, USA

2230. Volterra, E., Eubanks, R. A., and Muster, D., An investigation of the dynamic properties of plastics and rubber-like materials, *Proc. Soc. exp. Stress Anal.* **13,** 1, 85–96, 1955.

Paper describes experiments on impact loading of plastics and rubber-like materials. Specimen is mounted on a steel rod suspended as a ballistic pendulum, and a second rod, also as a pendulum, is permitted to strike specimen. Duration and displacement of impact is measured photographically. Elastic modulus and viscous modulus are determined and tabulated for four materials. Method of analysis and an estimate of the accuracy of experiments are discussed in appendix.

W. B. Stiles, USA

Mechanics of Forming and Cutting

(See also Rev. 2144)

Book—2231. Siebel, E., and Beisswanger, H., edited by, Deep drawing. Research papers in the field of deep drawing sponsored by the Research Society on sheet metals [Tiefziehen. Forschungsarbeiten auf dem Gebiete des Tiefziehens im Auftrage der Forschungsgesellschaft Blechverarbeitung], München, Carl Hanser Verlag, 1955. 205 pp.

A collection of well-illustrated and extensive papers by Siebel, et al., on such topics as deep drawing, limits of deformation experiments with tinfoil and cold-worked blanks, deep drawing under hydrostatic pressure, etc., is presented. A very good discussion of proper stress distribution in deep-drawn shells for maintenance of constant sheet thickness, as well as the mechanics of avoiding folds and tearing during drawing process, has been included. Lengthy bibliographies accompany most chapters and a wealth of design data and equations are included. Unfortunately, too few derivations are shown, making it difficult to compare analytical solutions with experimental data presented. Final chapter on electric resistance strain gages is superfluous since it is too incomplete to be of practical use. J. Frisch, USA

2232. Sejournet, J., Origin of the invention of steel extrusion by glass lubrication, *J. Franklin Inst.* **261,** 3, 315–318, Mar. 1956.

2233. Kuhne, H.-J., Common principles for the evaluation of experimental results on plastic forming, Part I and II (in German), *Technik* 9, 3, 4; 143–148; 225–231; Mar., Apr. 1954.

Author discusses the practical applicability of theories of plastic forming processes. The elementary or "equilibrium" theory is considered to be too complicated and also deficient in many respects (the advanced or slip-line theory is not mentioned). It is suggested that all experimental evidence be based on the most simple concept of frictionless and homogeneous plastic flow (FINK).

This results in equations which contain only a material constant and one geometrical variable. These equations, as well as test data for unit forming forces or stresses in dependence of the suitably selected variable, usually appear as straight lines in double-log representation. These indicate how much higher the actual forming force is than that derived from the concept of frictionless and homogeneous plastic flow. The author also discusses several specific processes, namely extrusion, wire drawing, and upsetting. G. Sachs, USA

2234. Niedzwiedzki, A., How to understand chip formation and tool wear, *Amer. Machinist* **100,** 7, 102–105, Mar. 1956.

2235. Hagen, J. F., and Lindberg, E. E., Design considerations applying to specification of surface finish for machined parts, *GM Engng. J.* **1,** 7, 12–17, July–Aug. 1954.

2236. Hinchliff, S., and Jones, J. W., The application of subsonic vibrations during solidification of castings with particular reference to a material for gas turbine blades, "H. R. Crown Max," *Coll. Aero. Cranfield Rep.* no. 89, 23 pp. w/appendix + 16 figs., Apr. 1955.

The report considers the theoretical relations between microstructures of castings and their mechanical properties and the possible effects and advantages of vibration during solidification; the design of a melting furnace and a mechanical vibrator to be used together; and the use of sillimanite bonded with ethyl silicate as a material for molds to withstand vibration.

It is concluded that the process of vibration gives a smaller and more equi-axed crystal grain structure and that the expected improvement in mechanical properties is realized. These changes for castings of H. R. Crown Max poured at a temperature of 1550 C, a frequency of 48 vps, and an amplitude of 0.005 in. are as follows:

	Nonvibrated	Vibrated
Ultimate strength t.s.i.	37.2	43.2
Elastic Limit	16	21.5
Elongation per cent	33	41
Reduction in area per cent	27	36
Balanced Impact ft lbs	9.6	13
Grain Size (grains per sq cm)	3	15

Both amplitude and frequency are contributory factors, but the latter is more important. From authors' summary

Hydraulics; Cavitation; Transport

(See also Revs. 2096, 2282, 2331, 2341, 2343, 2365, 2401, 2405, 2407)

2237. Bull, T. H., The tensile strengths of liquids under dynamic loading, *Phil. Mag.* (8) **1**, 2, 153-165, Feb. 1956.

A method of measuring the dynamic tensile strengths of liquids, involving the use of an electrical pressure bar, is described. Cavitation phenomena in water subjected to large transient tensile stresses have been observed using a spark shadowgraph technique. Under similar conditions of transient loading the cavitation thresholds of water and of glycerol are approximately 17×10^6 dynes/cm^2 and 63×10^6 dynes/cm^2, respectively. From author's summary by H. H. Anderson, Scotland

2238. Güth, W., An experiment for demonstration of cavitation bubbles and cavitation nuclei (in German), *Acustica* **5**, 3, 192-195, 1955.

The interesting apparatus to make the demonstration experiment is assembled from easily available electrical and optical parts and a water-filled beaker with diaphragm; the latter, when subjected to a pressure pulse by a spark, causes cavitation when receding. A second spark with adjustable time-setting from the first gives illumination for projection of the different stages of growth and collapse of successive cavitation clouds, which are similar enough to give a general idea of the process, but not for deeper study. A. Hollander, USA

2239. Tao, L. N., and Donovan, W. F., Through-flow in concentric and eccentric annuli of fine clearance with and without relative motion of the boundaries, *Trans. ASME* **77**, 8, 1291-1301, Nov. 1955.

The determination of laminar and turbulent flows through small, nonserrated passages of annular cross section is important in turbomachinery design. Authors precisely define such passages as, "one or more spaces bounded axially by two cylindrical bodies of slightly different diameters, nesting with varying degrees of eccentricity." In addition to the geometric variables involved, authors' analytical and experimental investigation concentrates on effects of rotational speed and eccentricity of the inner wall.

Authors assume friction factor $f = C/Re^n$ (Re is Reynolds number based on diametral clearance and C and n are constants) and flow is essentially that between two flat plates for ratios of inner wall diameter to diametral clearance considered. Effect of inner wall rotation is introduced by a transformation in which the mean axial velocity in the basic relation for stationary case is replaced by the mean absolute velocity and the passage length is increased in proportion to the rotational component. Thus, for same flow, pressure drop increases as $(\sec \alpha)^{1-n}$ where α is arctan (*rotational component/axial component*). Relations for ratio of eccentric flow to concentric flow, applicable to both stationary and rotating walls, are derived for laminar and turbulent flow. Laminar flow relation is same as that derived in hydrodynamic lubrication theory. Flow picture used in treatment of turbulent flow, particularly in rotating case, is somewhat oversimplified; however, relation indicates correct trend. Authors show that Schneckenberg's assumption of constant f [*ZAMM* **11**, 27-40, 1931] is only valid at high Re values where n tends toward zero.

Experimental investigation encompassed Re numbers from 800 to 30,000, radial clearances of 0.003 to 0.015 in., passage lengths of 2 to 4 in., eccentricities of 0 to 1, and rotational speeds of 0 to 3580 rpm for a nominal inner wall diameter of 3 in. Test results show, for stationary, concentric case, $C = 170$, $n = 1.03$ for laminar flow (compared to $C = 96$, $n = 1$ from hydrodynamic theory) and $C = 0.316$, $n = 0.21$ for turbulent flow. Authors believe f values are higher than those found in previous investigations due to inclusion of entrance and exit losses in determining f. As entrance and exit geometries influence magnitudes of these losses, caution must be exercised in applying authors' results to cases in which entrance and exit geometries differ appreciably from those used in this investigation, particularly for short passages.

The secant variation for the addition of a rotational velocity component is verified experimentally. Thus, laminar flows are essentially independent of rotational component, while turbulent flows decrease as this component increases.

Experimental data for effects of eccentricity show enough scatter as to allow only a qualitative verification of theoretical relation. Scatter is attributed to small, uncontrolled variations in eccentricities and radial clearances.

Paper includes useful design nomographs, based on experimental data, relating flow to significant design parameters for laminar and turbulent flows.

Reviewer believes paper to be a significant contribution to literature and an excellent foundation for future work on the subject.

H. E. Brandmaier, USA

2240. Franke, P., Jet contraction in flow under sluice gates in rectangular channels (in German), *Bautechnik* **32**, 8, 257-259, Aug. 1955.

Analytical study is based on energy considerations of the flow under a sluice gate in a rectangular channel. Author computes the downstream depth in the case where energy losses are neglected and in the case where they are taken into consideration. Values of the coefficient of contraction are given for different ratios of upstream depth to gate opening. All results are expressed in dimensionless form.

A. L. Jorissen, USA

2241. Zienkiewicz, O. C., Stability of parallel-branch and differential surge tanks, *Instn. mech. Engrs. Preprint*, 9 pp., 1955.

Author develops the mathematical theory of the stability of small oscillations in surge tanks of the parallel-branch type. Supposing the adjustment is ideal and the oscillations of the flow and water-levels are small, author finds the differential equations giving the limits of stability in all particular cases. In a general way, the results confirm Thoma's theory concerning ordinary surge tanks and are in accordance with those obtained for surge tanks with a restricted orifice.

In brief, this report represents a very important contribution to the study of the stability in surge tanks. L. Escande, France

2242. Lapturev, N. V., A local scour in the tailwater (in Russian), *Gidrotekh. Stroit.* **24**, 6, 37-40, 1955.

This is a most serious discussion of an article by M. S. Vyzgo [AMR **8**, Rev. 1711]. Writer discovers several substantial errors admitted in derivation of formulas by Vyzgo. Thus all conclusions are annihilated.

S. Kolupaila, USA

2243. Taraĭmovich, I. I., Problem of local scour beyond a horizontal apron in the tailwater (in Russian), *Gidrotekh. Stroit.* **24**, 5, 38-40, 1955.

This is a further contribution to an article by M. S. Vyzgo [AMR **8**, Rev. 1711]; writer offers his own formula, better corresponding to observations, as: $L/h_c = 4.25\,(v/z)^{-0.77}$, where L is the length of apron, h_c a critical depth, v limiting maximum velocity, z level difference on a spillway. S. Kolupaila, USA

2244. Anonymous, Salinity tests of existing channel, *Wwys. Exp. Sta. tech. Memo.* no. 2-337, 38 pp. + 6 tables, 8 photos., 50 plates, June 1954.

2245. Anonymous, Plans for the improvement of Grays Harbor and Point Chehalis, Washington. Hydraulic model investigation, *Wwys. Exp. Sta. tech. Memo.* no. 2-417, v + 79 pp. + 8 tables, 34 photos., 24 plates, Nov. 1955.

Incompressible Flow: Laminar; Viscous

(See also Revs. 2096, 2142, 2185, 2239, 2241, 2262, 2267, 2282, 2288, 2295, 2296, 2297, 2298, 2306, 2307, 2308, 2314, 2318, 2321, 2330, 2331, 2348, 2368, 2369, 2380, 2382, 2385, 2397, 2398, 2400, 2401, 2402, 2403, 2407, 2417)

2246. Bullard, E., Introduction. (A discussion on magnetohydrodynamics), *Proc. roy. Soc. Lond. (A)* **233**, 1194, 289–296, Dec. 1955.

This introduction to the papers dealt with in the following reviews is a brief but stimulating account of the principles of magnetohydrodynamics, i.e., of the mechanics of a fluid which is also an electrical conductor satisfying Ohm's law. Author describes the governing equations and the approximations on which they are based, and indicates the various lines along which the subject has been developed. He notes that the vexed question of the possibility that a moving fluid can generate a magnetic field in the way that a dynamo does is not yet fully resolved. G. K. Batchelor, England

2247. Chandrasekhar, S., Hydromagnetic turbulence. I. A deductive theory. II. An elementary theory. (A discussion on magnetohydrodynamics), *Proc. roy. Soc. Lond. (A)* **233**, 1194, 322–350, Dec. 1955.

Part I. The author assumes the existence of stationary isotropic turbulence in a conducting fluid, and writes down the corresponding tensor form of a number of mean products of the velocity and magnetic field at two different positions and times. By assuming that fourth-order cumulants of the joint probability distribution of the velocity and magnetic field are zero, he is able to obtain two partial differential equations for the two scalar functions defining the covariances of the velocity and the magnetic field.

Part II. An alternative way of determining the wave-number spectra of kinetic and magnetic energy is presented here. It is assumed that the rates of conversion of kinetic energy at one wave number to magnetic energy at another wave number, and vice versa, can be represented by expressions analogous to that suggested by Heisenberg in ordinary turbulence theory. The results are worked out for the case of stationary isotropic turbulence in fluid with zero viscosity and infinite conductivity. G. K. Batchelor, England

2248. Shercliff, J. A., Some engineering applications of magnetohydrodynamics. (A discussion on magneto-hydrodynamics), *Proc. roy. Soc. Lond. (A)* **233**, 1194, 396–401, Dec. 1955.

A number of problems arising from the use of electromagnetic flow meters are described. Such flowmeters have been in use for many years, but only recently have they been used with fluids of sufficiently large conductivity for the magnetic field and the motion of the fluid to have an appreciable effect on each other. Steady-state profiles for laminar flow in a tube in the presence of a transverse magnetic field, the corresponding entry-length problem (which is of particular interest in the operation of flowmeters), and the effect of upstream disturbances are all considered. G. K. Batchelor, England

Book—2249. Pai, S.-I., Fluid dynamics of jets, New York, D. Van Nostrand Company, Inc., 1954, xi + 227 pp. $5.

This is an interesting use of the "core" technique (sometimes used in elementary school programs), wherein the author covers a wide range of classes of fluid dynamical approximations tied together by the common thread of application to a particular class of boundary conditions, those associated with what we call "jets." The following kinds are discussed: (a) Inviscid, constant density; (b) inviscid, subsonic; (c) inviscid, supersonic; (d) laminar (viscous) zero Mach number, and constant density; (e) laminar, finite Mach number; (f) laminar, zero Mach number but variable density; (g) turbulent, zero Mach number, constant density; (h) turbulent, zero Mach number, variable density; (i) turbulent, finite Mach number; (j) stability of some of the (above) inviscid and laminar flows. The last half of the book contains a good deal of the author's published analytical work.

In reviewer's opinion, this interesting pedagogical effort will be helpful to engineers seeking a bird's-eye view of jet flows. It seems, however, to lack the depth and physical insight essential for the research student in basic fluid mechanics. Of course, this may be due to space limitations, but there are also a number of questionable assertions and briefly-statable omissions. For example:

On page 73, the inclusion of laminar jets is "justified" by the implication that the (hot) exhaust of a jet engine may be laminar.

On page 77 and elsewhere, the similarity assumption is not explicitly identified.

On page 83, it is asserted that in a small perturbation jet the longitudinal and lateral perturbation velocities are of the same order; continuity prevents this.

On page 96, Reynolds is cited as having discovered "the fundamental facts of turbulent flow." We are still some way from the facts.

On page 97, Reichardt's analysis is described as essentially a constant exchange-coefficient analysis. This seems at variance with the facts.

Figures 5.1, 5.6, 5.9 are misleading.

On page 113, Prandtl is apparently credited with priority in use of the turbulent energy equation. Apart from Reynolds (1895) and later workers who applied it to determination of lower critical Reynolds number, this equation was applied to turbulent shear flow distributions by von Karman [*J. aero. Sci.* 1937]. On page 129, Karman is given the priority.

On page 117, Reichardt's theory is described as "somewhat more logical" than the mixing-length theories, a moot description.

On page 142 it is reported that Abramovich finds that a more dense jet spreads at a wider angle (for fixed density of receiving medium). That this contradicts both experiment and other analyses is not mentioned.

Chap. VII on "Jet mixing of gases of different kinds" contains a number of unclear statements.

The introduction to chap. VIII on "Stability" describes a dichotomy of opinion on the cause of transition which is quite unknown to the reviewer. S. Corrsin, USA

2250. Loos, H. G., Compressibility effects on secondary flows, *J. aero. Sci.* **23**, 1, 76–80, Jan. 1956.

Author develops the equation for the change of streamwise, or secondary, component of vorticity along a streamline in the compressible, inviscid, steady flow of a perfect gas in terms of the gradients of stagnation temperature and entropy. The equation is applied to the flow in the end walls of a compressor cascade, and compressibility is shown to cause an increase in the secondary vorticity. Apart from this, compressibility does not affect the calculation of the induced secondary velocities in the linearized theory. Reviewer suggests that it is easier to work in terms of the gradients of stagnation temperature and stagnation pressure, for then analysis [W. R. Hawthorne, "The growth of secondary circulation in frictionless flow," *Proc. Camb. phil. Soc.* **51**, pt. 4, 737–743, 1955; AMR **8**, Rev. 1419] shows that the growth of secondary vorticity is the result of a gradient in stagnation pressure only.
W. R. Hawthorne, USA

2251. Benton, G. S., The effect of the earth's rotation on laminar flow in pipes, ASME Ann. Meet., Chicago, Ill., Nov. 1955. Pap 55-A-9, 15 pp.

Author presents a rational solution to the viscous flow equation with the Coriolis term retained in order to study the influence of the rotation of the earth upon the laminar flow in pipes. The intensity of weak secondary circulations in the cross-sectional plane is found to be proportional to the ratio of the Reynolds number and the Rossby number. The Rossby number is the ratio of the inertia forces to the Coriolis forces. It is written as $V/2\omega D \sin \alpha$, where V and D are, respectively, the fluid velocity and characteristic length of the system, ω is the angular velocity of the earth's rotation, and α is the angle between the axis of the earth's rotation and the direction of fluid motion. For small values of the Rossby number such as found in meteorology (order of 10^{-1}), the rotation of the earth is of prime importance. In small-scale hydraulic experiments this number is of the order of 10^5, and it has heretofore been assumed that the effect of the earth's rotation may be completely ignored in such cases. Comparison of axial flow profiles as computed and as carefully measured in a 1-in. tube showed that the actual excursion in axial flow component to be roughly one third as large as predicted by the theory.

Author feels encouraged that a consistant effect is observed and believes that the relatively short length of pipe (35 ft) available in the experiment may be too short to achieve the full development of the secondary flows. It is conjectured that the effects of such small asymmetries in the velocity profile may be important in regard to the stability of the laminar flow state. J. P. Breslin, USA

2252. **Hansen, A. G., and Herzig, H. Z., Cross flows in laminar incompressible boundary layers,** *NACA TN* 3651, 50 pp., Feb. 1956.

Three-dimensional boundary layers are considered in the case when the free-stream velocity components normal and parallel to the leading edge are of the forms U = constant and $W = \Sigma a_i x^i$, respectively, where x is the distance from the leading edge. The u and v components of the velocity in the boundary layer are given by the standard Blasius solution, while the w component is given by a simple summation in terms of universal functions. Extensive tabulations of the required functions are presented for cases involving W polynomials up to degree ten. Flow-visualization experimental checks for the theory are provided for several flow configurations. Authors suggest that the theoretical results should provide qualitative information regarding certain aspects of the behavior of turbomachine boundary layers. D. W. Dunn, USA

2253. **Yih, C.-S., Maximum acceleration in two-dimensional steady flows of an ideal fluid,** *Quart. appl. Math.* **13**, 2, 202–203, July 1955.

2254. **Yih, C.-S., Stability of two-dimensional parallel flows for three-dimensional disturbances,** *Quart. appl. Math.* **12**, 4, 434–435, Jan. 1955.

2255. **Laufer, J., The structure of turbulence in fully developed pipe flow,** *NACA Rep.* 1175, 18 pp., 1954.

See AMR **7**, Rev. 208.

2256. **Lewis, W., and Brun, R. J., Impingement of water droplets on a rectangular half body in a two-dimensional incompressible flow field,** *NACA TN* 3658, 27 pp., Feb. 1956.

Trajectories of water droplets moving in the ideal two-dimensional flow field ahead of a body of rectangular cross section and infinite extent in the downstream direction have been calculated by means of a differential analyzer. Data on collection efficiency and distribution of water impingement are presented. From authors' summary

2257. **McCormick, B. W., An approximation to the lift of a two-dimensional cascade of airfoils,** *J. aero. Sci.* **22**, 10, 730–731, Oct. 1955.

2258. **Hantush, M. S., and Jacob, C. E., Plane potential flow of ground water with linear leakage,** *Trans. Amer. geophys. Un.* **35**, 6, part 1, 917–936, Dec. 1954.

Compressible Flow, Gas Dynamics

(See also Revs. 2104, 2105, 2236, 2250, 2254, 2280, 2288, 2308, 2310, 2317, 2326, 2327, 2342, 2348, 2359, 2372, 2374, 2379, 2385, 2390, 2391)

2259. **Legendre, R., Supersonic flow around a slender body** (in French), *C. R. Acad. Sci. Paris* **242**, 6, 730–732, Feb. 1956.

Using curvilinear coordinates based on the Mach cone, the author deduces the potential for a slender body at zero incidence. In this method the strength of the source distribution is related to the area of the body cut off by adjacent Mach cones having their centers on the axis OX. This leads to an "area rule" which differs considerably from that using transverse sections for an aircraft with wings swept through an angle close to the Mach angle. A. W. Babister, Scotland

2260. **Bogdonoff, S. M., and Hammitt, A. G., Fluid dynamic effects at speeds from M = 11 to 15,** *J. aero. Sci.* **23**, 2, 108–116, 145, Feb. 1956.

The phenomena of viscous-inviscid interaction effects at very high speeds over the fore part of bodies have been studied at speeds considerably higher than those previously investigated. A tunnel, using helium as a working fluid, has been developed for these studies and has been operated at speeds up to $M = 15$. Pressure distributions have been obtained over the fore part of some simple bodies: a flat plate, two wedges, and a cone. In addition, schlieren and interferometric photographs have been taken. The results show that extremely high pressures, as high as ten times the values predicted by inviscid theories, are obtained over the region close to the nose of the body. Although some aspects of the theoretical work on this problem appear to be correct, the numerical values of the pressures obtained are considerably different than predicted—on the order of two to three times as large. This difference may be explained by the influence of the leading edge, and some preliminary results on the effect of leading edge thickness indicate the primary importance of the leading-edge region with its associated highly curved shock.

From authors' summary by M. H. Bertram, USA

2261. **Oguchi, H., Supersonic jet with the ambient pressure corresponding to its constant pressure point,** *J. phys. Soc. Japan* **11**, 2, 155–159, Feb. 1956.

A two-dimensional, steady and slightly supersonic flow of jet discharging into a medium at rest of ambient pressure corresponding to the constant pressure point of the shock polar is analyzed by the hodograph method with transonic approximation. Analytic expression of the stream function is obtained. The shock pattern is discussed and the velocity distribution along the axis of the jet is calculated. It was found that the constant pressure point in the case of a free jet plays the same role as the Crocco point in the case of the finite wedge. S. I. Pai, USA

2262. **Oswatitsch, K., Potential flow vorticity (cascade) for supersonic flow** (in German), *Z. Flugwiss.* **4**, 1/2, 53–57, Jan./Feb. 1956.

The problem of nonviscous supersonic flow through cascades is solved in the following way: For the change from parallel supersonic flow into vorticity potential flow and vice versa, a construction is given that is based on the well-known method of characteristics. With the aid of such transition pieces, potential flow vortex cascades with arbitrary Mach number at the intake and the exit and of arbitrary deflection angle can be constructed. Finally, some practical requirements are discussed. The method is illustrated by an example. R. Sauer, Germany

2263. **Fenain, M., and Germain, P., On the solution of the equation governing in the second approximation the flow around a three-dimensional body** (in French), *C. R. Acad. Sci. Paris* **241**, 3, 276–278, July 1955.

Procedure is developed for iterating on Busemann's conical flow theory for flat wings lying inside the Mach cone. Second-order solution is sketched for nonlifting flat diamond cone. Useful similarity rule is found for surface pressure such that solutions for various Mach numbers and planform angles form only a single-parameter family. Numerical results differ from those of Moore [AMR **4**, Rev. 2572] and Tan (reproduced by Lighthill in AMR **8**, Rev. 1094), which predicted enormous second-order effects. (Reviewer understands latter results are now known to be erroneous.) M. D. Van Dyke, USA

2264. **Visich, M., Jr., Supersonic flow around pointed three-dimensional bodies. Part I, Description of the method,** *Polyt. Inst. Brooklyn, Aero. Lab. Rep.* 280 A, 32 pp., July 1955.

The flow field about general three-dimensional bodies of arbitrary cross section is determined by perturbation of a basic conical flow pattern. The procedure involves first finding the shape of the shock surface which will cause the flow to follow the body contours; then the velocity components downstream of the shock surface can be computed.

Since the position of the shock is not easily expressed in terms of the body coordinates, the solution is not generally in closed form. The properties of the flow field at arbitrary points behind the shock can be computed, however, permitting investigation of engine inlet conditions and similar applications. L. H. Schindel, USA

2265. **Giese, J. H., On the equations of linearized conical flow,** *Quart. appl. Math.* **13**, 2, 206–208, July 1955.

2266. **Yur'ev, I. N., Linearized theory of the supersonic flow of gas around a body of revolution** (in Russian), *Prikl. Mat. Mekh.* **19**, 3, 363–367, 1955.

Approximate method is derived for calculating pressure on portions of axisymmetric body away from pointed ends. Linearized equation is transformed to characteristic coordinates, and coefficient of first derivatives are approximated by function permitting closed solution. In appli-

cation of method, linear first-order ordinary differential equation must be solved for each body shape and Mach number. Solution for parabolic boattail $r = 0.25 - 0.125\ x^2$ at $M = 2$ is shown to compare fairly well with exact solution by characteristics method back to $x = 1$, where radius is halved. More pertinent, reviewer finds agreement to within 10 % with true linearized solution calculated numerically using high-speed machinery. Note that pressures in Fig. 2 are one tenth of values indicated

M. D. Van Dyke, USA

2267. Campbell, I. J., and Lewis, R. G., Pressure distributions: Axially symmetric bodies in oblique flow, *Aero. Res. Counc. Lond. curr. Pap.* no. 213, 10 pp. + 8 figs., 1955.

A simple picture, known from the work of I. Lotz, of the flow over the forward part of a body of revolution in oblique flow is derived here from entirely elementary considerations. The pressure at any point of the (forward part of the) body at any angle of incidence depends on three parameters whose values vary along the body. The variation of these parameters along the body can be determined from a relatively small number of wind-tunnel or water-tunnel measurements. The necessary water-tunnel measurements have been made for four axially symmetric head shapes. Additional measurements have been made to illustrate the theoretical conclusions. The data for each head shape are adequate for a determination of the pressure coefficient at any point on the head shapes at any angle of incidence (up to 6°, say). In particular, they can be used to determine the peak suction at any angle of incidence and so the conditions for the onset of cavitation on the head.

From authors' summary

2268. Grib, A. A., and Riabinin, A. G., Approximate integration of equations for two-dimensional stationary supersonic gas flow (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **100**, 3, 425–428, 1955.

Author gives an approximate solution of equations for two-dimensional stationary supersonic gas flow for Mach numbers contained in the interval $1.15 \leq M \leq 2.35$, using for this interval of Mach numbers an approximate equation

$$\alpha \doteq \sigma$$

where

$$\alpha = \arcsin(1/M),\ \sigma = 1 - \int_1^{\lambda} (\lambda^2 - 1)/[1 - (\kappa - 1/\kappa + 1)\lambda^2]^{1/2} \cdot (d\lambda/\lambda),\quad \lambda = W/a.$$

He makes use of these results to solve some boundary-value problems for two-dimensional supersonic gas flow. In the end author remarks that for $M > 2.35$ it is possible to approximate to the function $\alpha = \alpha/\sigma$ by the linear function

$$\alpha \doteq 0.236\sigma + 0.284$$

from which one can obtain, in certain cases, an approximate solution for those Mach numbers.

J. Polášek, Czechoslovakia

2269. Zusin-Molozhen, L. M., and Shapiro, I. G., Certain results on the supercritical flow around (in Russian), *Teploenergetika* **2**, 3, 34–37, 1955 (translated from Russian by M. D. Friedman, 572 California St., Newtonville, Mass., 7 pp).

The interferograms shown in this paper and previous one [See AMR **9**, Rev. 1884] for a variety of steam-turbine-type cascades appear to add nothing significant to what is already generally known from similar studies in this country. The usefulness of the work is limited by the poor quality of the photographs and the lack of any mention of the theory of their blade designs.

J. V. Becker, USA

2270. Grodzovskiĭ, G. L., Flow of a viscous gas between two parallel flat walls in motion and between two rotating cylinders (in Russian), *Prikl. Mat. Mekh.* **19**, 1, 99–102, 1955.

The exact solutions for the equations of motion of the two kinds of steady flow of a viscous incompressible fluid mentioned in the title are well known. The author discusses the exact solutions for the same two kinds of flow of a viscous compressible gas.

E. Leimanis, Canada

2271. Talbot, L., Viscosity corrections to cone probes in rarefied supersonic flow at a nominal Mach number of 4, *NACA TN* 3219, 39 pp., Nov. 1954.

Pressure data of cone probes with semivertex angle $\theta = 5°$ have been obtained for free stream $1 < M < 6$ and $250 < Re_x < 1000$. The location and hole size of the pressure orifice and the diameter of the cylindrical afterbody have been varied. The results indicate that all these variables influence the $C_p(M, \theta, Re_x)$ relation in quite a complex way. Each of these effects will require further investigation.

Y. K. Jan, Holland

2272. Marson, G. B., The calculation of the wave drag of a family of low-drag axi-symmetric nose shapes of fineness ratio 4.5 at zero incidence at supersonic speeds, *Coll. Aero. Cranfield Note* no. 10, 15 pp. + 5 figs., May 1954.

The pressure drag coefficients of a particular family of convex logarithmic projectile nose shapes in which the nose angle is an important parameter have been calculated over a range of supersonic Mach numbers using a rapid approximate method due to Zienkiewicz.

The optimum nose angle for minimum wave drag of these profiles for each Mach number has been obtained. It is shown that above $M = 1.5$, approximately, the optimum shape is similar to the hypersonic optimum profile and has the same or less wave drag than this profile. However, for values of M/F below 0.5, where F is the fineness ratio, both the hypersonic and the logarithmic optimum profiles have a higher drag than the so-called cubic profile.

From author's summary

2273. Marson, G. B., Keates, R. E., and Socha, W., An experimental investigation of the pressure distribution on five bodies of revolution at Mach numbers of 2.45 and 3.19, *Coll. Aero. Cranfield Rep.* no. 79, 13 pp. + 18 figs., Apr. 1954.

Measurements have been made in the College of Aeronautics 2½ in. × 2½ in. intermittent high-speed tunnel of the pressure distributions on five non-lifting bodies of revolution of different nose angles at zero incidence. The tests were made at Mach numbers of 2.45 and 3.19.

The results are compared with the pressure distributions given by two approximate theoretical methods, and good agreement is found at the Mach numbers used.

From authors' summary

2274. Sibulkin, M., Theoretical and experimental investigation of additive drag, *NACA Rep.* 1187, 12 pp., 1954.

The significance of additive drag is discussed and equations for determining its approximate value are derived for annular- and open-nose inlets. Charts are presented which give values of additive drag coefficient over a range of free-stream Mach numbers for open- and for annular-nose inlets with conical flow at the inlet. The effects on additive drag of variable inlet-total-pressure recovery and static pressures on the centerbody are investigated, and an analytical method of predicting the variation of pressure on the centerbody with mass-flow ratio is given.

Experimental additive-drag values are presented for a series of 20° and 25° cone half-angle inlets and one open-nose inlet operating at free-stream Mach numbers of 1.8 and 1.6. A comparison with the theoretical values of additive drag shows excellent agreement for the open-nose inlet and moderately good agreement for the annular inlets.

From author's summary by R. M. Crane, USA

2275. Sinnot, C. S., A method of computing subsonic and transonic plane flows, *Aero. Res. Counc. Lond. curr. Pap.* no. 173, 14 pp. + 10 figs., Sept. 1953.

This paper presents a relaxation treatment of a simple but exact differential equation for compressible flow. The method has advantages over other numerical treatments of the same problem and, because of the simplicity of the basic differential equation, should be particularly suitable for high-speed computing machines.

The flow about a 10% thick airfoil (RAE 104 section) at zero incidence is calculated for Mach numbers of 0.70, 0.79, and 0.86. At $M = 0.86$ the existence, but not the position, of a transonic shock wave is predicted by the relaxation technique. Satisfactory agreement with experiment is obtained.

From author's summary

Wave Motion in Fluids

(See also Rev. 2415)

2276. Cartwright, D. E., On determining the directions of waves from a ship at sea, *Proc. roy. Soc. Lond. (A)* **234**, 1198, 382–387, Feb. 1956.

Paper describes method developed at the National Institute of Ocean-

ography, Great Britain, for measuring frequency, velocity, and direction of waves at sea. Method is dependent on records from shipborne wave recorder [Tucker, AMR **6**, Rev. 1769]. Principle measures Doppler shift in each frequency component of the wave-energy spectrum in a 12-minute wave record due to motion of ship along a given course. By causing ship to complete a dodecagonal circuit at constant speed, (circa 7 knots) so that directions vary successively by 30°, the variation in Doppler shift of the predominant wave frequency present can be identified in the estimated wave-energy spectrum for each cruise direction. Wave-energy spectra are computed from squares of Fourier harmonics of records obtained from the automatic wave analyzer at N.I.O. Plots of predominant wave component frequency versus bearing angle provide convincing evidence of consistent change of Doppler shift with ship direction. Position of minimum frequency gives bearing to which waves or swells are travelling; mean frequency defines significant wave period. Amplitude of sinusoidal Doppler shift determines phase velocity which is found to agree within 5% with theoretical phase velocity of long-crested waves at mean frequency.

Paper includes mathematical discussion of principles and presents results of field experiments. One example revealed superposed local wind waves and distant swell from widely different directions. Reviewer considers method ingenious and powerful tool in scientific elucidation of confused wave conditions at sea. B. W. Wilson, USA

2277. **Korvin-Kroukovsky, B. V., and Lewis, E. V., Ship motions in regular and irregular seas,** *Inter. Shipbldg. Progr.* **2,** 6, 81–94, 1955.

In the first part of the paper authors extend Weinblum's and St. Denis' work described in *SNAME* papers of 1950 and 1951. They introduce coupling between heave and pitch motions. The simultaneous differential equations obtained are assumed to be linear and the coefficients to be constant and independent of time. Evaluation of constants is described clearly. The entire forcing functions were measured experimentally. Calculated and experimental results are compared, using a model of DTMB series 60, having a 0.60 block, wave length equal to model length, height of wave 1/48 of the length. Good correlation was obtained as to pitching. Due to high discrepancy between experimental heave data of different laboratories, a complete verification of computational procedure was not possible. Coupling between heave and pitch motions is, however, shown to be very important.

In second part, authors discuss the possibility of studying ship motions in irregular seas. They state that the current development of analytical and experimental techniques for ship-motion studies is not yet adequate to deal with the problem unless simplified to a two-dimensional problem, i.e., all irregularity in transverse direction is neglected. It is noted that any irregular ocean surface, analyzed statistically, shows a distribution curve close to the Gaussian one when deviation from base line at equal time intervals is plotted on the basis of frequency of occurence. As a conclusion, the apparent irregularity of the sea and of ship motions may be considered simply to be the sum of a very large number of regular waves and motions superimposed. (As reviewer can see, analytical treatment of the problem along these lines presupposes coefficients of simultaneous differential equation to be independent of frequency of oscillation, which is not the case.)

Authors conclude further that a legitimate simplification is obtained if a long-crested sea is obtained for studies of symmetrical motions. Created irregular long-crested waves in model tank at the E.T.T. is shown to give distribution curves close to the Gaussian one, i.e., similar to ocean seas. E. Steneroth, Sweden

2278. **Richardson, E. G., An ultrasonic apparatus for recording the height of water waves in model ship tanks,** *J. sci. Instrum.* **33,** 3, 91–92, Mar. 1956.

An apparatus is described for measuring the height of water waves on the surface of a model ship towing or maneuvering tank. The apparatus uses an ultrasonic transducer on the bed. This pulses toward the surfaces and the echoes returned from successive crests and troughs are recorded continuously on an oscillograph. From author's summary

Turbulence, Boundary Layer, etc.

(See also Revs. 2239, 2249, 2252, 2255, 2309, 2370, 2373, 2374, 2375, 2379, 2381, 2415)

2279. **Stüper, J., The effect of surface excrescencies on the transition of the boundary layer over a plate** (in German), *Z. Flugwiss.* **4,** 1/2, 30–34, Jan./Feb. 1956.

Laminar-turbulent transition in boundary layer on flat plate was studied using hot-wire anemometer located at various distances from leading edge and by measurements of velocity distribution at trailing edge, both with and without pressure gradient along surface. Apparatus consisted of 1.68-m glass plate installed in low-turbulence wind tunnel, the fall in pressure toward trailing edge being produced by a decrease in tunnel cross section. Transverse piano wires 0.31 to 1.22 mm in diam were attached to plate 17.8 or 60.9 cm from leading edge so that sensitivity of boundary layer could be compared with and without favorable pressure gradient.

Acceleration of main air stream did not make boundary layer more resistant to disturbing influence of wires. Surface friction coefficients computed from observed momentum thicknesses agreed with well-known formulas of Blasius and Schlichting at low and high Reynolds numbers, respectively; the transition occurring earlier, the larger the wire. Observed critical values of Reynolds number based on boundary-layer momentum thickness $U\theta/\nu$ were approximately 835 for wires smaller than 0.4 mm, decreasing to approximately 420 for the largest wire tested. R. L. Pigford, USA

2280. **Laufer, J., Experimental observation of laminar boundary-layer oscillations in supersonic flow,** *J. aero. Sci.* **23,** 2, 184–185 (Readers' Forum), Feb. 1956.

2281. **Mangler, K. W., Calculation of the laminar boundary layer for an arbitrary pressure distribution for any Mach number** (in German), *Z. Flugwiss.* **4,** 1/2, 63–66, Jan./Feb. 1956.

Author has developed a new numerical approximative method which permits the calculation of the laminar boundary layer for an arbitrary pressure distribution and temperature distribution along the wall for any Mach number. The dependence of the viscosity and the Prandtl number on the temperature is allowed for. This method, therefore, represents an essential generalization of the method of Stewartson [*Proc. roy. Soc. Lond. (A)* **200,** 84–100, 1949; AMR **3,** Rev. 2019] and is less coarse than the similar method of Meksyn [ibid **231,** 274–280, 1955]. By introducing two appropriate auxiliary functions whose qualitative behavior at least can be recognized from the first due to certain special cases, author obtains the reduction of the problem to a symmetrically built pair of partial differential equations suitable for a numerical treatment and computation. The first step is already expected to be a good approximation of the solution function. Author speaks of "iteration" method, but reviewer believes that, for the considered "continuation problem" of the boundary-layer theory, the notation "step-by-step method" is more suitable (as it implicitly contains the iterative security of each computation step). M. Schaefer, Germany

2282. **Chernyi, G. G., Laminar gas and fluid motions in a boundary layer which contains a discontinuous surface** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 12, 38–67, Dec. 1954.

For laminar two-dimensional motions in a boundary layer which contains a discontinuous surface, a system of equations of general character is set up. The diffusion of the medium and the surface tensions have been neglected.

The system of equations is solved for two specific cases: (a) Flow around a plane porous plate, with the liquid seeping through the plate, while the discontinuous surface is impenetrable for the liquid; and (b) flow around a plane plate with a cross motion through the discontinuous surface (e.g., condensation of steam flowing around a plane plate).

In either case, it has been assumed that the local velocities and the local temperatures across the discontinuous surface are continuous. M. Strscheletzky, Germany

2283. **Lachmann, G. V., Laminarisation through boundary layer control,** *AGARD Publications* AG 14/P 5, 108–127, May 1954.

See AMR **8,** Rev. 2442.

2284. **Wadhwa, Y. D., On boundary-layer thickness,** *ZAMM* **35,** 8, 295–300, Aug. 1955.

2285. **Klebanoff, P. S., Schubauer, G. B., and Tidstrom, K. D., Measurements of the effect of two-dimensional and three-dimensional roughness elements on boundary-layer transition,** *J. aero. Sci.* **22,** 11, 803–804, Nov. 1955.

2286. Chamberlain, J. W., and Roberts, P. H., Turbulence spectrum in Chandrasekhar's theory, *Phys. Rev.* (2) **99,** 6, 1674-1677, Sept. 1955.

The authors do in wave-number space what Chandrasekhar [AMR **8,** Rev. 2802] has done in physical space for stationary isotropic turbulence. On the whole, the results do not seem to be very realistic.

G. K. Batchelor, England

2287. Munk, M. M., A simplified theory of turbulent fluid motion, with application to the Couette flow, Catholic Univ. Amer. (Prepared by way of partial performance under Contract no. N6onr 255, Task V, awarded by ONR), part I and II, 68 pp., June 1955.

This unpublished report is apparently the work whose appearance we were bidden to watch for in an earlier paper by the author [AMR **8,** p. 221 (feature article)]. Great claims were made in that earlier paper, and the same aggressive and pretentious style characterizes the present work. The content scarcely measures up to the claims made for it, although it provides some interesting suggestions. Current thought about turbulence is in the doldrums, and provocative attempts like this to take a new and uninhibited view of the subject may well be valuable.

The purpose of the report, apart from the polemics, is to consider turbulent motion, and plane Couette flow in particular, at Reynolds numbers not too far above the critical value at which sustained turbulent motion first becomes possible. This is a new idea, most of the past research on turbulent motion being concerned with the high Reynolds number state at which viscosity has a negligible effect on all but the small eddies containing appreciable vorticity but negligible energy. The author considers the equation expressing the balance of turbulent energy, and postulates expressions for the various terms to suit the afore-mentioned range of Reynolds numbers. The most important of these postulates is that the mixing of fluid elements is limited by the restraining influence of viscosity, the corresponding expression for the eddy diffusivity then being proportional—so it is argued, on the basis of a concrete picture of a mixing element as something like a decaying Hill's spherical vortex—to the product of the Reynolds number of the turbulence, a representative length, and a representative velocity. The arguments presented in support of this expression for the diffusivity are not conclusive, but it has a plausible form. Author then uses the energy equation to make some predictions about plane Couette flow, although no experimental results are available for comparison. It might be possible to make a similar analysis of circular Couette motion, which can more readily be studied experimentally.

G. K. Batchelor, England

Aerodynamics of Flight; Wind Forces

(See also Revs. 2263, 2274, 2305, 2306, 2307, 2308, 2309, 2312, 2323, 2324, 2325, 2341, 2344, 2345, 2346, 2350, 2400)

2288. von Karman, T., Nondimensional quantities in aerodynamics and related subjects (in German), *Z. Flugwiss.* **4,** 1/2, 3-5, Jan./Feb. 1956.

In the domain of the science of aerodynamics, the dimensionless characteristic parameters such as Reynolds, Mach, Prandtl, Péclet, and Schmidt numbers are currently used.

In the domain of aerothermodynamics, for example, if the elevation of temperature due to chemical reaction in the system should be taken into consideration, as in the case of the burning velocity in premixed fuel and air, such terms as the heat of reaction, the velocity coefficient of chemical reaction should be introduced into the dimensionless groups containing the thermal diffusivity.

I. Sawai, Japan

2289. Jones, R. T., Minimum wave drag for arbitrary arrangements of wings and bodies, *NACA TN* 3530, 11 pp., Feb. 1956.

Under the assumptions that the total lift and the total volume of the aircraft are given, conditions that must be satisfied if the drag (at supersonic speeds) is to be a minimum are found. For arbitrary regions the minimum value can be estimated by a simple formula giving a lower bound.

From author's summary by A. Petroff, USA

2290. Kuhn, R. E., Investigation of the effects of ground proximity and propeller position on the effectiveness of a wing with large-chord slotted flaps in redirecting propeller slipstreams downward for vertical take-off, *NACA TN* 3629, 38 pp., Mar. 1956.

An investigation of the effects of ground proximity and propeller position on the effectiveness of a wing equipped with large-chord slotted flaps in redirecting the slipstreams from large-diameter propellers downward for vertical take-off has been conducted in a static-thrust facility at the Langley Aeronatuical Laboratory.

The results indicate that, with the propeller thrust axis on the wing chord plane, both the angle through which the slipstream is deflected and the ratio of resultant force to thrust are reduced as the ground is approached. At positions nearest the ground some of the loss in resultant force is regained. Lowering the thrust axis below the wing chord plane reduces the adverse effects of the ground and also reduces the large diving moments associated with the slotted-flap arrangement. The static-thrust efficiency of the propellers is slightly reduced by the ground effect.

From author's summary

2291. Kuchemann, D., The nonlinear rise of the over-all lift of rectangular wings with low aspect ratio (in German), *Z. Flugwiss.* **4,** 1/2, 70-73, Jan./Feb. 1956.

Two methods formerly suggested by A. Betz are considered to obtain a nonlinear lift theory of wings with low aspect ratio in incompressible flow. In the first, a free vortex sheet is taken starting from the leading edge and the tip edges, so that a full separation over the whole wing area occurs. That gives the lift formula: $c_l = 2\sin^2\alpha$ which also agrees with Bollay's theory. The second method works with a free vortex sheet starting only from the tip edges. Therefore no separation occurs on the leading edge. The result is: $c_l = (\pi/2)\cdot A\cdot\alpha + (\pi/2)\alpha^2$. Both theories are compared with former measurements of rectangular wings.

E. Scholz, Germany

2292. Daley, B. N., and Dick, R. S., Effect of thickness, camber, and thickness distribution on airfoil characteristics at Mach numbers up to 1.0, *NACA TN* 3607, 75 pp., Mar. 1956.

Tests of a group of related NACA airfoil sections varying in maximum thickness, design lift coefficient, and thickness distribution have been conducted in a two-dimensional open-throat type of wind tunnel at Mach numbers of 0.3 to about 1.0 and at corresponding Reynolds numbers from 0.7×10^6 to 1.6×10^6. Normal-force, drag, and pitching-moment coefficients are presented, together with representative schlieren photographs and pressure-distribution diagrams.

The results of these tests indicate that at near-sonic speeds the maximum ratio of the normal force to drag ($(n/d)_{max}$) approaches the low values theoretically determined for a biconvex airfoil in supersonic flow; contrary to low-speed results, the $(n/d)_{max}$ increased as either the thickness ratio or the camber was decreased. At all Mach numbers the normal-force coefficient for $(n/d)_{max}$ generally increased with increases in thickness ratio and camber and with forward movement of the position of maximum thickness. The trends of the data in the highest Mach number range indicated that the normal-force-curve slopes of all airfoils tested are approximately equal to Mach number 1.0, the value being about the same as at low speeds.

From authors' summary

2293. Katzen, E. D., Limitations of linear theory in predicting the pressure distribution on triangular wings, *J. aero. Sci.* **22,** 7, 514-515, July 1955.

The purpose of this note is to call attention to the fact that even for relatively thin, low-aspect-ratio wings the local surface slopes may be sufficiently large so that linear theory cannot be used for calculating the lift distribution, even at angles of attack as small as 3°.

From author's summary

2294. Malavard, L., Duquenne, R., Enselme, M., and Grandjean, C., Properties of delta wings with swept or straight trailing edges calculated by the electric tank method (in French), *ONERA NT* 25, 61 pp., 1955.

Direct analogy to cross-flow potential in linearized subsonic lifting-surface theory is evaluated for family of 30 swept trapezoidal wings. Plan form parameters varied are sweep of leading and trailing edges, and taper ratio. Results include pressure distributions, and lift-curve slope and center of pressure for complete wings as well as for chordwise sections. Special consideration is given to pressure distribution in neighborhood of apex and to influence of rounding the tips. Compre-

hensive comparison with earlier calculations and with approximate methods is given. Reviewer believes calculations are most accurate ones available for such a large family of wings.

S. B. Berndt, Sweden

2295. **Helmbold, H. B., On the lift of a blowing wing** (in German), *Ing.-Arch.* **23**, 3, 209–211, 1955.

Author considers the flow around and forces on an airfoil from which a jet issues at the trailing edge in a direction tangential to the surface. It is known that the additional lift of the wing due to the presence of the jet is greater than the downward component of the excess-momentum flux of the jet, and author considers how this arises from the additional circulation which is produced by the deflection of the jet by the basic flow. A formula is given for the lift due to this additional circulation. Furthermore, an integral equation is given for the shape and strength of the vortex sheet which, in the theory, replaces the jet.

J. T. Stuart, England

2296. **Eppler, R., Calculation of airfoils from pressure distribution** (in German), *Ing.-Arch.* **23**, 6, 436–452, 1955.

Paper deals with the steady two-dimensional potential theoretical problem. Following assumptions should be mentioned: (1) Airfoil coordinates have been introduced as functions $x(\varphi)$, $y(\varphi)$ in terms of Fourier series. Instead of velocity $v(\varphi)$, function $v(\varphi)\cdot(1 + y'^2)^{1/2}$ (with $y' = dy/dx$) has been used, which differs from $v(\varphi)$ near leading edge only; (2) angle of attack α and c_a, respectively, may be chosen freely; (3) given distribution of velocity must be checked in advance to decide whether the airfoil shape is closed; if not, it must be changed; $\omega(0)$ should be finite and $y_{\varphi}(0) = 0$; (4) $\omega(\varphi)$ may be assumed in such a way that velocity distribution takes a given (e.g., constant) shape on a limited part of upper side for a value c_{a_1} and, also, on another limited part on lower side for another c_{a_2}. Practical calculation has been carried out with interpolation formulas. Method is illustrated by two examples.

F. W. Riegels, Germany

2297. **Fauquet, A., The application of the theory of lifting lines to wings equipped with spoilers** (in French), *Publ. sci. tech. Min. Air France* no. 289, 79 pp. + 4 tables, 1954.

Paper deals with a rather extensive application of the theory of finite span airfoils in incompressible flow to the case of a wing equipped with spoilers for lateral control. The basic theory of Prandtl as developed by Pérès and Malavard in the form of numerical tables is employed. Calculations are made of rolling and yawing moments on a wing equipped with a series of spoilers of varying spans and locations relative to the main wing.

Wind-tunnel tests in a selected number of cases indicate good agreement with theory and the suitability of the Pérès-Malavard tables for application to the spoiler problem. The notation is distinctly different from that employed in the United States, due apparently to the desirability of following the work of Pérès and Malavard.

M. J. Thompson, USA

2298. **Queijo, M. J., Theoretical span load distributions and rolling moments for sideslipping wings of arbitrary plan form in incompressible flow,** *NACA TN* 3605, 45 pp., Dec. 1955.

A simplified method is given for calculating spanwise loads due to sideslip, if the loading at zero sideslip is known. Modified lifting-line method is used, the trailing vortexes being parallel to the plane of symmetry back to the trailing edge and thereafter parallel to the relative wind. It is assumed that circulation distribution is the same as for wing at zero sideslip. The rolling moment due to sideslip can be found either by integration of the loading distribution or by summing the effects of a number of horseshoe vortexes. A small empirical correction is added to C_{l_β} to account for effects of sideslip on the circulation distribution.

Charts are given enabling C_{l_β}/C_L to be found for straight tapered swept wings. Much better agreement with experimental results is, in general, obtained with the above method than with that of *NACA TN* 1581.

A. W. Babister, Scotland

2299. **Plaskowski, Z., New starting method for aircraft: the point start** (in German), *Flugwehr u. Technik* no. 6, 143–147, June 1955.

This is a steep start from narrow spot. Airplane is prepared on a stationary or movable frame and started into the desired direction by an auxiliary rocket additional to its own driving force. This method is especially of military interest. Calculation of starting force, initial velocity, and steepness is derived from a dynamic equation. For engineering, a numeral example is presented where the fastest and the steepest start are set off.

P.-P. Heusinger, Germany

2300. **Schulz, G., Aerodynamic rules for the attachment of jet engines,** *Z. Flugwiss.* **3**, 5, 119–129, May 1955.

Aerodynamically, the efficient attachment of jet-engine nacelles to aircraft is more difficult than in the case of piston engines. Although the latter type require freedom for the operation of the propeller, they impose less restrictions on the design. For example, the jet engine presents difficulties in front of the inlet and aft of the exhaust, in undercarriage location, and in installation location. Based on present experience, eight fundamental rules of general applicability are drafted regarding the positioning of the jet-engine nacelles. These rules cover the effect of nacelle location on drag satisfactorily. (In general, the results agree with recent wind-tunnel data from the NACA.) However, more data are required on the effect of nacelle location on maximum lift and pitching moment. Several diagrams are also presented which help to clarify the eight basic rules.

G. B. White, USA

2301. **Carpenter, P. J., Shivers, J. P., and Lee, E. E., Jr., Investigation of the propulsive characteristics of a helicopter-type pulse-jet engine over a range of Mach numbers and angle of yaw,** *NACA TN* 3625, 24 pp., Jan. 1956.

The nonwhirling propulsive characteristics of a helicopter-type pulse-jet engine mounted on a simulated rotor blade have been determined in the Langley 16-ft transonic tunnel. A propulsive thrust of about 1 lb/sq in. of engine frontal area at Mach numbers from 0.25 to 0.45 was obtained. Propulsive thrust at Mach number 0.6 decreased to about 0.73 lb/sq in. frontal area. Yaw angles of 0° to 20° had no significant effect on engine thrust at Mach numbers below 0.5 and only small effects at higher speeds. Specific fuel consumption reached a minimum of 5.3 lb of fuel per hr per hp between Mach numbers of 0.4 and 0.5. Comparison of whirling and nonwhirling data indicates significant performance losses due to whirling above centrifugal accelerations of about 200g.

From authors' summary.

2302. **Berman, A., Response matrix method of rotor blade analysis,** *J. aero. Sci.* **23**, 2, 155–161, 172, Feb. 1956.

The most accurate of the available methods of rotor-blade-bending analysis involve the tabular solution of a differential equation [AMR **5**, Rev 2908]. In order to simplify the calculations and retain the desired accuracy, a matrix method is presented which permits the calculation of the blade response—i.e., bending moment, curvature, slope, deflection—for any loading and harmonic without repeating solutions of the differential equation. Consequently, when a number of different loadings are to be investigated, the method greatly reduces the labor involved and, therefore, offers considerable advantage.

L. Goland, USA

2303. **Houbolt, J. C., Walls, J. H., and Smiley, R. F., On spectral analysis of runway roughness and loads developed during taxiing,** *NACA TN* 3484, 9 pp., July 1955.

The application of the technique of generalized harmonic analysis as a means for determining airplane taxiing loads is considered in a cursory manner. Some results on runway roughness are reviewed and some results obtained from taxiing tests of a large airplane are given. An elementary extrapolation of results for low taxiing velocities to higher velocities is shown to be conservative. Also, oleo-strut friction is shown to be a very important factor. With regard to the load-prediction phase of taxiing loads by spectral techniques, much additional work is required, especially with respect to the treatment of the transfer function.

From authors' summary.

Aeroelasticity (Flutter, Divergence, etc.)

2304. **Jordan, P. F., An investigation on panel flutter** (in German), *Z. Flugwiss.* **4**, 1/2, 67–70, Jan./Feb. 1956.

The stability of a traveling wave along a thin panel is studied on the assumption that aerodynamic forces are proportional to local slope. Author concludes critical flutter speed is equal to wave speed for same wave length in still air and states this is in agreement with reviewer's more accurate analysis ["On the aerodynamic instability of thin

panels," Ramo-Wooldridge Rep. AM 5-2a, May, 1955] and with simple wind-tunnel tests on paper flag. Reviewer notes that his results agree with author's only for light structures (such as paper flag tested) or hypersonic speeds but not for metal panels of practical dimensions at moderate (subsonic or supersonic) speeds. Author suggests amplitude of flutter might be limited by nonlinear increase of wave speed and by discontinuous decreases of wave length with increased speed and that panel, while unstable in usual sense, would appear stable in virtue of very small amplitudes. Author reports paper panel tested at $M = 5$ was stable, but no mention is made of dynamic pressure. Reviewer's results yield monotonic increase of *negative* damping factor with dynamic pressure and he believes that much more experimental evidence is required to justify author's conclusion that instability will be unobservable at high speeds.

J. W. Miles, USA

2305. Huckel, V., Tabulation of the f_λ functions which occur in the aerodynamic theory of oscillating wings in supersonic flow, *NACA TN* 3606, 59 pp., Feb. 1956.

The integrals which are denoted as the f_λ functions and which occur in the aerodynamic theory for wings oscillating in pure supersonic flow have been evaluated and tabulated for various Mach numbers and values of the reduced frequency. Specific values of parameters λ, M, and k for which tabulations of f_λ are presented are: $\lambda = 0$ to 11; Mach numbers of 1.2, 1.3, 1.4, 1.5, 1.6, 1.8, 2.0, 2.5, 3.0, 3.5, 4.0, and 5.0; and values of the reduced frequency k from 0 to 2.0 at the following intervals - 0(0.005)0.15, 0.15(0.01)0.2, 0.2(0.025)0.35, 0.35(0.05)1.0, and 1.0(0.1) 2.0. The tabulated values are considered accurate to one in the last digit.

From author's summary

2306. Whitmarsh, G. E., Measurement of the derivative z_w for oscillating sweptback wings, *Coll. Aero. Cranfield Rep.* no. 92, 13 pp. + 24 figs., July 1955.

Measurements have been made of the derivative z_w for rigid sweptback wings mounted at zero incidence and oscillated with simple harmonic motion. The Reynolds number was in the range 1.2×10^5 to 4.1×10^5.

The wings were of trapezoidal planform, chosen to indicate the effects of sweepback, aspect ratio, and taper ratio. In each case the variation of z_w with frequency parameter was determined, and the effect of amplitude of oscillation checked, and found to be fairly small.

It was found that the effects of the planform parameters on the derivative were, in general, similar to those on lift curve slope. The curves obtained, however, suggested higher values of $(-z_w)$ than given by theory for zero frequency parameter, in all cases.

From author's summary

2307. Milne, R. D., and Willcox, F. G., Measurement of the derivative z_w for oscillating wings in cascade, *Coll. Aero. Cranfield Rep.* no. 93, 15 pp. + 29 figs., July 1955.

Experimental results are reported of the damping derivative z_w for rigid rectangular wings of various aspect ratios in cascades having gap-chord ratios of 2, 1, 1/2, 1/3, 1/4. The results show fair agreement with two-dimensional theory. The ranges of Reynolds numbers and frequency parameters were 0.8 to 2.5×10^5 and 0.1 to 0.45, respectively.

The results show a strong dependence on Reynolds number which increases with decrease in gap-chord ratio. This effect was eliminated by transition fixation by wires placed at suitable positions downstream of the wing leading edge.

From authors' summary

2308. Burger, A. P., On the asymptotic solution of wave propagation and oscillation problems, *Nat. LuchtLab. Amsterdam Rap.* no. F. 157, 97 pp., Nov. 1954.

Report (thesis at Technological University, Delft) deals with a method for solving wave diffraction about a strip at high frequencies. The wave equation $\Delta\varphi + k^2\varphi = 0$ is regarded as resulting by a Fourier transform from the hyperbolic equation $\Delta\psi - \psi_{tt} = 0$. Boundary conditions at the strip (φ_n = given) then transform problem into the problem of a rectangular wing, at incidence in a supersonic flow (of infinite chord) which can be solved by Evvard's (or Ward's) method. Solution builds up from successive regions of interaction, and a recursion formula is derived. For small values of the chordwise coordinate, solution can be given explicitly. Transforming back, solution for original problem, valid at high frequencies, is obtained.

Method is applied to problem of acoustic diffraction at a strip and confirms Kirchhoff's approximation. Since transonic approximation for oscillating airfoils at subsonic flow is governed by the same equation, where $k = yl/e(1 - m^2)$, the method for determination of aerodynamic derivatives in transonic flow (linearized approximation) is outlined. In particular, the calculation of the "singular solution" is considered.

R. Timman, Holland

2309. Rhees, T. R., and Crenshaw, W. P., Some effects of viscosity on wing-body interference at M = 1.9, *J. aero. Sci.* **23,** 1, 43-48, Jan. 1956.

Pressure distribution data are presented for the body of a flat rectangular wing-cylindrical body combination, both with a laminar boundary layer on the body and with a turbulent boundary layer on the body. These results are compared with the linearized inviscid theory of *NACA TN* 2677, 1952.

The experimental results agree well with the theoretical pressures except for some viscous effects which are discussed in detail. These viscous effects tend to average out for the body loading. Qualitative similarity of the three-dimensional shock-wave and boundary-layer interaction to the two-dimensional case is noted.

Where comparable, the results of this paper are in accord with the experimental results of *NACA TN* 3128, 1954.

W. C. Pitts, USA

2310. Bailey, H. E., and Phinney, R. E., Some experimental results on wing-body interference at supersonic speeds, *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 697-704.

Extensive experimental investigations of pressure distribution on the body are made in order to test the range of validity of a linearized theory. The cylindrical body has zero angle of incidence, the wing -8^0, 0^0, $+8^0$. The test results are discussed in detail and give a qualitative understanding of the effects of viscosity on wing-body interaction.

A. Betz, Germany

2311. Fraeys de Veubeke, B. M., Iteration in semidefinite eigenvalue problems, *J. aero. Sci.* **22,** 10, 710-720, Oct. 1955.

General rules are derived for setting up iteration matrixes yielding convergence toward the elastic modes of semidefinite self-adjoint vibration problems. They are classified according to the methods used for a preliminary reduction of the problem to a finite number of degrees of freedom. These include the Rayleigh-Ritz, the complementary energy, and the integral equation approach. In the last case, it is shown how extended influence coefficients are related to isostatic reference frames. A numerical example is treated and a procedure suggested for improving the higher frequency modes obtained from the lumped mass models which are provided by the application of numerical integration and collocation to the integral equation.

From author's summary by G. C. K. Yeh, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 2116, 2135, 2301, 2302, 2336, 2381)

Book—2312. Mangham, E., and Peace, A., Jet engine manual, New York, Philosophical Library, Inc., 1955, 133 pp. $3.75.

Book is a question-and-answer description of turbojet and turboprop aircraft engine operation. Fuel, lubricant, and starter systems are included, as well as chapters on installation and trouble-shooting.

Written primarily for those directly concerned with the operation and maintenance of these aircraft engine types, the book is a valuable reference for any engineer interested in jet-powered flight.

Pocket size is convenient, type is good, and illustrations, not profuse, are well chosen. Book is a practical presentation entirely and theory is included only as needed for clarification.

C. H. Yuill, USA

2313. Rainbow, H. S., The design of small jet engines, *J. roy. aero. Soc.* **59,** 532, 249-258, Apr. 1955.

2314. Friedrich, H., On the influence of incidence on the performance of a turbine runner (in German), *Brennstoff-Wärme-Kraft* **8,** 1, 9-15, Jan. 1956.

Several types of blading were tested on a turbine wheel at different speeds and different heat drops. Flow speed coefficient and blade efficiency as conventionally defined were found to drop more rapidly with

increasing positive incidences than with negative ones, the maxima being generally at slightly negative incidence, with respect to the leading-edge tangent to the skeleton line. Outlet directions deviated by constant angles from the trailing-edge tangents except at high positive incidence.

From these results, author denounces usual steam-turbine design practice with positive incidence.

Explanation concerning effect of degree of reaction on efficiency is not convincing. L. S. Dzung, Switzerland

2315. **Kreuter, K., Performance of axial-flow steam turbine under large speed variations** (in German), *Brennstoff-Wärme-Kraft* **8,** 1, 16–22, Jan. 1956.

Test results of efficiency and torque variations with speed changes are compiled from publications, including author's own, dated between 1908 to 1950. It was found that, at constant flow and constant heat drop, efficiency and torque follow similar curves when plotted against speeds. The curves of the same turbine type (Curtis wheel, single-stage impulse, multistage impulse, drum-type reaction) coincide if all performance values are plotted as fractions of the values at maximum-efficiency point. For instance, zero-speed torque is about 2.0, 2.2, 2.5, 2.9 times torque at maximum efficiency, respectively, for the afore-named types.

Certain relation between efficiency and Parson's coefficient could be established. L. S. Dzung, Switzerland

2316. **Zickuhr, W., On the optimum design speed of drum-type steam turbines** (in German), *Brennstoff-Wärme-Kraft* **8,** 1, 23–25, Jan. 1956.

Assuming the turbine shaft to have simple geometrical shape, author derives in a previous paper [*Siemens-Z.* **28,** 5, 189–196, 1954] the expressions of steam-turbine loss coefficients and critical speed as functions of design parameters. The condition for lowest blade clearance loss for constant profile width is found to be such that the ratio of total length to bladed length of shaft is about 2. Other conditions are also cited. These conditions are related to the critical speed in a unique, but algebraically not entirely simple, manner which is not given explicitly by author.

Author's reasoning is sometimes difficult to follow.

L. S. Dzung, Switzerland

2317. **Stewart, W. L., Analysis of two-dimensional compressible-flow loss characteristics downstream of turbomachine blade rows in terms of basic boundary-layer characteristics,** *NACA TN* 3515, 48 pp., July 1955.

The loss coefficients at the trailing edges and downstream of the bladings of a two-dimensional cascade are calculated in terms of the trailing-edge boundary-layer characteristics. Compressible power profiles are assumed and complete mixing of the wake downstream of the blades is considered. Results indicate a small effect of compressibility on the loss coefficient based on loss in kinetic energy, whereas the coefficient based on loss in total pressure is considerably influenced by the free-stream Mach number. Effects of the trailing-edge thickness are also studied. They compare favorably with experimental data.

The accuracy of the results obtained from this analysis depends on the knowledge of the boundary-layer displacement thickness, and particularly the momentum thickness. This is fortunate, as this latter can be obtained more readily from boundary calculations. N. Van Le, USA

2318. **Zhukovskiĭ, M. I., and Sknar, N. A., New cascades of turbine profiles** (in Russian), *Teploenergetika* **2,** 1, 7–12, 1955 (translated from Russian by M. D. Friedman, 572 California St., Newtonville, Mass., 11 pp.)

Paper presents data on four new profiles of turbine buckets designed at the Central Steam Turbine Institute in Russia. The proposed new profiles were developed for use in high- and medium-pressure stations. Among the advantages of the new profiles are their low sensitivities in variations in entry angle. The data presented, which also include some information on nozzle partitions, are based on stationary cascade tests. These data show that the profile energy losses do not exceed 3,5–4% with a wide range of cascade spacing for input angle variations from 27 to 40 deg. The flow exit angles varied from 23 to 26 deg. Corresponding losses of blading now used in Russia usually vary from 8 to 10%. Curves summarizing the test data are given, but the translation does not give cross-section pictures of the nozzles and buckets.

G. R. Fusner, USA

2319. **Trumpler, W. E., Jr., and Fox, E. A., Considerations in the mechanical design of high temperature steam turbines,** ASME Ann. Meet., N. Y., Nov. 1954. Pap. 54-A-234, 10 pp.

2320. **Wilson, C. D., Close-coupled cross-compound arrangement for compact large capability steam-turbine-generator units,** ASME Ann. Meet., N. Y., Nov. 1954. Pap. 54-A-182, 9 pp.

2321. **Scholz, N., Secondary flow losses in turbine cascades,** *J. aero. Sci.* **21,** 10, 707–708 (Readers' Forum), Oct. 1954.

2322. **Tsai, D. H., Effect of size on the inlet-system dynamics in four-stroke, single-cylinder engines,** *Trans. ASME* **78,** 1, 197–210, Jan. 1956.

Paper describes a study of the problem of dynamic similarity in inlet systems of four-stroke, single-cylinder engines with long inlet pipes. A similarity rule formulated from a consideration of unsteady, isentropic, one-dimensional flow of a compressible fluid in the inlet pipe is checked by experiments. From author's summary

2323. **Lüpke, H., A critical comparison of different engines for the driving of helicopters** (in German), *Z. Flugwiss.* **3,** 8, 260–270, Aug. 1955.

The suitability of various types of engines for driving helicopters is investigated briefly and the advantages and disadvantages are discussed. Finally, pay-loads of helicopters driven by various types of engines are compared and it is shown that also in the case of the helicopter, the choice of the type of engine for the aircraft depends on its task. From author's summary

2324. **Alverman, W., Jürgen, L., and Lohse, W., Comparison of engines with respect to their applicability in helicopters** (in German), *Z. Flugwiss.* **3,** 8, 271–287, Aug. 1955.

An attempt is made to summarize the points which are relevant for a suitable application of various types of engines for helicopters, with special reference to the effect of the power plant on the airframe. Though the piston engine will, in the future, remain the engine for the conventional helicopter, possibilities for the application of jet engines have arisen from the demand for greater horizontal speeds with the principle of the vertical lift craft principle remaining mainly for vertical take-off and vertical landing. From authors' summary

2325. **Knickrehm, H., Suitable engines for installations in helicopters** (in German), *Z. Flugwiss.* **3,** 8, 288–302, Aug. 1955.

In view of a revival of the design of helicopters, the problem regarding a suitable engine for the installation in the helicopter becomes topical. In the present paper, the engines so far used in helicopters are generally discussed first, then a compilation of the most usual types follows, with their features according to a critical comparison. Finally, distinctive characteristics are pointed out which ought to be observed when selecting the engine, and suitable types of engines are suggested.

From author's summary

2326. **Keusch, R. B., Effect of supersonic flight on power-plant installation systems,** *Trans. ASME* **77,** 5, 721–726, July 1955.

Paper treats power-plant installation-system problems either brought on or aggravated by supersonic flight. These problems are in addition to those (treated elsewhere) of the basic engine; their magnitude and possible effect on the aircraft mission are treated. Among the power-plant installation-system areas considered are fuel systems, lubrication systems, power transmission, engine placement, air-induction systems, and cooling systems. From author's summary

2327. **Benson, R. S., Discharge of gas from cylinder to atmosphere, Part 1, 2, 3,** *Engineer, Lond.* **199,** 5178, 5179, 5180; 546–548, 582–584, 618–620; Apr., May 1955.

The method of characteristics is employed to analyze the discharge of a gas from a cylinder to the atmosphere. The results show that a depression occurs in the cylinder for isentropic flow. The magnitude of the depression depends on the ratio of port area to cylinder area. The duration depends on initial pressure and temperature, cylinder length, and the ratio of port area to cylinder area. The effect of gradual or quick opening of the port is considered. Curves obtained by approximate methods give valuable qualitative information for two-cycle engines.

For example, a depression is more readily obtained with through-scavenged engines with high stroke-to-bore ratio, earlier port opening, and when the product of engine speed and cylinder length is high.

J. F. Lee, USA

Flow and Flight Test Techniques

(See also Revs. 2122, 2238, 2297, 2367, 2391)

2328. Brombacher, W. G., Smith, J. F., and Van der Pyl, L. M., Guide to instrumentation literature, *Nat. Bur. Stands. Circ.* 567, 156 pp., Dec. 1955. $1.00.

2329. Iversen, H. W., Orifice coefficients for Reynolds numbers from 4 to 50,000, *Trans. ASME* **78**, 2, 359–364, Feb. 1956.

Author states that the original intent of this survey was to establish standard orifice-meter coefficients in the low Reynolds number range. He concludes that the calibration results which are available in the literature for corner taps do not correlate within desired tolerances for standards. He also concludes that standardization of the complete orifice shape is essential for standard specifications of orifice-meter coefficients in the low Reynolds number range. Author presents a literature survey of orifice-meter coefficients for corner taps in the Reynolds number range of 4 to 10,000 (based on the pipe diameter) and for orifice to pipe diameter ratios of 0.1 to 0.8. He suggests the use of these data as a guide for comparison purposes, provided the approach pipe is long enough to insure the established pipe-line velocity distribution at the orifice.

R. N. Weltmann, USA

2330. Jorissen, A. L., Discharge measurements at low Reynolds numbers—Special devices, *Trans. ASME* **78**, 2, 365–368, Feb. 1956.

Paper is an analysis of the author's and other investigators' experimental data for discharge coefficients for various types of orifices, for two orifices in series, and for various types of nozzles. This work was done since constant-area differential types of fluid meters give best results if the discharge coefficient can be considered independent of Reynolds number. Frequently this is not the case at very low and very high Reynolds numbers. Author tabulated the ranges of Reynolds numbers for which the discharge coefficient remains constant for the different devices. He concludes that a number of devices, such as the quadrant-edge orifice and the cylindrical nozzle with and without diffuser, maintain constant discharge coefficients down to low Reynolds numbers.

R. N. Weltmann, USA

2331. Monroe, E. S., Jr., Flow of saturated boiler water through knife-edge orifices in series, *Trans. ASME* **78**, 2, 373–377, Feb. 1956.

Author presents a useful empirical relationship for the flow of saturated boiler water through from one to four thin-plate orifices arranged in series. This empirical equation agrees with the literature data and the author's experimental results when the back pressure at the orifice is near atmospheric condition. The effects of solids in solution in the water appeared negligible. All the types of thin-plate orifices tested gave comparable results; therefore, author feels that the flashing of the liquid into vapor is the more controlling factor than the variations in the orifice discharge coefficient. Stable flow conditions between expansions seemed to exist already at distances of six inches. The effect on flow when using more than two orifices in series was found negligible.

R. N. Weltmann, USA

2332. Aniansson, Gustaf, Aniansson, Gunnar, and Noren, O., Measurement of airflow with radioactive gas (in Swedish), *Tekn. Tidskr.* **86**, 2, 17–22, Jan. 1956.

Authors present a method of mapping the air flow in drying processes, used here in hay drying. The method uses a radioactive gas as tracer. Kr-85 has been chosen, being an inert gas and thus not absorbed in the hay. It has a long half-life (10 years) and is an almost pure β (0.65%γ), reducing health hazards to a minimum.

The detector consisted of 6 parallell GM-tubes connected to a portable, battery-operated scaler. A concentration of $1\mu C/m^3$ Kr-85 gives a net counting-rate of 1740 cpm (background 350 cpm). This concentration gives 1/30 of the permissible dose rate.

500 mC krypton, supplied in a glass ampoule, was transferred to a high-pressure bomb and diluted with nitrogen to a concentration of 2 mC/1. For continuous dosing of Kr-85, a Dalén flash-light valve was used, and for instantaneous introduction rubber bladders were used.

The method was applied to determination of the amount of recirculating air, the fan-blower capacity under varying conditions, the airflow pattern during drying, and the self-ventilation with the blower turned off.

Compared to measurements with pitot tubes, the present method gave considerably more reproducible results in determining fan-blower capacity, even if special ducts were used in the former case.

Authors suggest the method to be suitable also for ventilation studies in rooms, offices, factories, mines, etc.; for determining capacity of fan-blowers, air pumps, etc., and air speeds (down to very low values); for determining gas leakage, and for measuring recirculation in drying with air.

K. Ljunggren, Sweden

2333. Murdock, J. W., Foltz, C. J., and Gregory, C., Jr., Effect of a globe valve in approach piping on orifice-meter accuracy, *Trans. ASME* **78**, 2, 369–371, Feb. 1956.

Authors investigated experimentally the change of indicated flow rate of steam and water due to a globe valve placed upstream at various distances from the orifice meter. Measurements were made for orifice-to-pipe-diameter ratios of 0.30 to 0.74. Authors concluded that the straight pipe line between the globe valve and orifice meter can be less than the approach piping recommended by the joint AGA-ASME Committee on Orifice Meters. Authors found that the change in indicated flow rate if the globe valve is placed six diameters upstream of the orifice was less than 2% for all the orifices they tested.

R. N. Weltmann, USA

2334. Spengler, W., Theoretical basis and sources of errors of bubble gages (in German), *Wasserwirtschaft* **46**, 3, 69–75, Dec. 1955.

Following a brief history of the early use of this instrument, two types are described: that in which a continuous flow of gas maintains the lower bell empty, and that in which there is no flow of gas in the system. It is shown that the first type has a less-linear characteristic over the range most likely to be in use. Cumulative errors may be of the order of a few per cent, composed of constituent errors, each of which may, at most, amount to only a few per mil. The principal sources of error are temperature and atmospheric pressure, but errors in establishing the pressure of the gas in the system and friction in the indicating mechanism are also appreciable.

C. E. Balleisen, USA

2335. Diehl, E. J., and Visser, H., Measurement of rapidly fluctuating pressures, *Inter. Shipbldg. Progr.* **1**, 3, 138–144, 1954.

2336. Spahr, J. C., and Richards, R. L., Turbine supervisory instruments, ASME Ann. Meet., Chicago, Ill., Nov. 1955. Pap. 55-A-62, 9 pp., + 16 figs.

The operation and function of a complement of current turbine supervisory instruments are described. The instruments are shaft-eccentricity meter, cylinder-expansion meter, differential-expansion meter, flange differential-temperature meter, shaft-position meter with a hydraulic backup device, thrust meter, and shaft-vibration meter. Charts showing typical operating events are discussed. The present and future philosophies concerning the use of supervisory instruments are given in the conclusions.

From authors' summary

2337. Eveson, G. F., and Hall, E. W., A continuous-flow rotational viscometer for use with downward-settling suspensions, *J. sci. Instrum.* **33**, 3, 110–112, Mar. 1956.

A rotational viscometer is described capable of measuring the apparent viscosity of downward-settling suspensions of particles sized below 100 B.S. mesh, where the settling velocity of the particles relative to the dispersion medium is less than (0.2cm/s).

From authors' summary

2338. Maude, A. D., and Whitmore, R. L., The wall effect and the viscometry of suspensions, *Brit. J. appl. Phys.* **7**, 3, 98–102, Mar. 1956.

When the viscosity of a suspension of spherical particles uniformly distributed in a simple liquid is measured in a capillary tube viscometer, a wall effect, which is not found with coaxial rotating cylinder viscometers, is observed. The paper suggests that it may be caused by a redistribution of a portion of the suspension particles on entering the tube of the viscometer, leading to a reduction in both the concentration

and viscosity of the suspension near to the walls of the tube. The diminution in concentration is measured experimentally and found to yield a value for the wall effect which is in agreement with that obtained from viscosity measurements. The reason for the redistribution of the particles at the tube inlet is discussed.

From authors' summary

2339. **Arvay, L., Measurement of milliseconds** (in Hungarian), *Mérés és Automatika* **3**, 12, 381–384, Dec. 1955.

A simple method of measuring short time intervals is described, suitable for testing moving parts of automatic elements. The equipment, which can be put together in every average laboratory, consists of a condenser charged during the movement through a known resistance from a stabilized d c source. The voltage across the condenser measured by a vacuum-tube voltmeter is proportional with the time of the movement. With U_o as constant d c voltage, U_r and U_c the voltages across the resistance R and the condenser C, respectively, the time is given as $t = RC \ln U_o/(U_o - U_c)$. The results from a series of measurements are represented on a diagram showing that the voltage gives the time interval directly. The described method is suitable for measurements of 0.5–50 milliseconds, e.g., those of moving elements in magnetic fields, where the acceleration is not constant. Finally, the accuracy of the measuring method is critically treated and is given in a certain case as approximately ± 10%, without use of highly precise instruments.

A. Lenkei, Hungary

2340. **Sobol, A. P., and Evans, J. S., Investigation of the use of the thermal decomposition of nitrous oxide to produce hypersonic flow of a gas closely resembling air,** *NACA TN* 3624, 36 pp., Mar. 1956.

The possibility of using thermal decomposition of nitrous oxide (N_2O) to produce a high-pressure and high-temperature gas, similar to air and suitable for hypersonic studies, was investigated experimentally.

Pressures up to 1930 atm and temperatures up to 1860°K were observed in the constant-volume decomposition of N_2O, which was 97.2% (by volume) complete at these peak conditions. At a constant pressure of 37.4 atm, a temperature of 1645°K was observed, with 84% complete decomposition.

Hot decomposition products of N_2O were used in a hypersonic nozzle at supply pressures up to 70 atm. A Mach number of up to 7.6 was obtained, and the nozzle wall pressure distribution showed good agreement with the distribution obtained with air in the same nozzle and with theoretical (one-dimensional, isentropic) values.

J. Lukasiewicz, Canada

2341. **Bryant, R. A. A., The size of aerofoil models for quantitative hydraulic analogy research,** *J. roy. aero. Soc.* **60**, 543, 208–209, Mar. 1956.

2342. **Sherman, F. S., A low-density wind-tunnel study of shock-wave structure and relaxation phenomena in gases,** *NACA TN* 3298, 83 pp., July 1955.

The profiles and thicknesses of normal shock waves of moderate strength have been determined experimentally in terms of the variation of the equilibrium temperature of an insulated transverse cylinder in free-molecule flow. The shock waves were produced in a steady state in the jet of a low-density wind tunnel, at initial Mach numbers of 1.72 and 1.82 in helium and 1.78, 1.85, 1.90, 1.98, 3.70, and 3.91 in air. The shock thickness, determined from the maximum slope of the cylinder temperature profile, varied from 5 to 3-½ times the length of the Maxwell mean free path in the supersonic stream. A comparison between the experimental shock profiles and various theoretical predictions leads to the tentative conclusions that: (1) The Navier-Stokes equations are adequate for the description of the shock transition for initial Mach numbers up to 2, and (2) the effects of rotational relaxation times in air can be accounted for by the introduction of a "second" or "bulk" viscosity coefficient equal to about two-thirds of the ordinary shear viscosity.

From author's summary by H. P. Liepman, USA

2343. **Van Manen, J. D., Tests in cavitation tunnels and their comparison with open-water tests,** *Inter. Shipbldg. Progr.* **1**, 3, 149–155, 1954.

2344. **Jackson, H. H., Rumsey, C. B., and Chauvin, L. T., Flight measurements of drag and base pressure of a fin-stabilized parabolic body of revolution (NACA RM-10) at different Reynolds numbers and at Mach numbers from 0.9 to 3.3,** *NACA TN* 3320, 20 pp., Nov. 1954.

Free-flight tests at supersonic speeds have been made to determine the Reynolds number effects on total drag and base drag of a fin-stabilized parabolic-arc body of revolution having a body fineness ratio of 12.2 and designated the NACA RM-10 configuration. The Reynolds number range of 14×10^6 to 210×10^6 was obtained by testing full-scale and half-scale models through the Mach number range from 0.9 to 3.3.

From authors' summary.

2345. **Aiken, W. S., Jr., and Wiener, B., Analysis of the horizontal-tail loads measured in flight on a multiengine jet bomber,** *NACA TN* 3479, 69 pp., Sept. 1955.

Horizontal-tail loads were measured in gradual and abrupt longitudinal maneuvers on two configurations of a four-engine jet bomber. The results obtained have been analyzed to determine the flight values of the coefficients important in calculations of horizontal-tail loads. The least-squares procedure used to determine aerodynamic tail loads from strain-gage measurements of structural tail loads which were affected by temperature is covered in detail. The effect of fuselage flexibility on the airplane motion is considered in the analysis of the abrupt-maneuver data. When possible, wind-tunnel results are compared with flight results. Some calculations of critical horizontal-tail loads beyond the range of the tests are given and compared with design loads.

From authors' summary.

2346. **Vincenti, W. G., Measurements of the effects of finite span on the pressure distribution over double-wedge wings at Mach numbers near shock attachment,** *NACA TN* 3522, 50 pp., Sept. 1955.

Results are presented of measurements at low supersonic speeds of the pressure distribution on tow wings having a common double-wedge section and aspect ratios 2 and 4. Comparable results for aspect ratio infinity have been published in *NACA TN* 3225. The results cover the Mach number range from 1.166 to 1.377, which brackets the value (1.221) for bow-wave attachment at zero angle of attack. The data are discussed and compared with the previous two-dimensional findings.

From author's summary.

2347. **Dods, J. B., Jr., and Tinling, B. E., Summary of results of a wind-tunnel investigation of nine related horizontal tails,** *NACA TN* 3497, 105 pp., July 1955.

A compilation of data is presented for models of nine related horizontal tails. The majority of the results were obtained at a Mach number of approximately 0.20. Three of the models were tested throughout the subsonic Mach number range to a maximum of 0.94. The Reynolds number range was from 2 to 4 million. The models had aspect ratios from 2 to 6, angles of sweepback from 5.7° to 45°, and had 30% chord, sealed, plain flaps. The lift coefficient, hinge-moment coefficient, and pressure coefficients across the elevator nose seal are presented. The effects of sweepback, aspect ratio, and Mach number on the lift and hinge-moment parameters are summarized. Comparisons of the experimental results with theoretical calculations are presented.

From authors' summary.

2348. **Mitchell, J. L., and Peck, R. F., An NACA vane-type angle-of-attack indicator for use at subsonic and supersonic speeds,** *NACA TN* 3441, 8 pp., May 1955.

A description is presented of a vane-type angle-of-attack indicator developed by the NACA for use at supersonic and subsonic speeds. A brief history of the development and a wind-tunnel calibration are given together with a discussion of the corrections to be applied to the indicated readings.

From authors' summary.

2349. **Anderson, A. B. C., Structure and velocity of the periodic vortex-ring flow pattern of a *primary Pfeifenton* (Pipe tone) jet,** *J. acoust. Soc. Amer.* **27**, 6, 1048–1053, Nov. 1955.

Visualization of the vortex flow pattern in typical *primary Pfeifenton* jets was made by means of shadow graph techniques to show the transition in form of the vortex pattern as it moves downstream in the jet, as well as the dependence of the downstream translational vortex velocity and the geometry of the vortex pattern on the Reynolds number of the jet.

Results of experiment are compared with available theory. These studies were carried out with carbon dioxide jets discharging into the

atmosphere. The flow channel geometry consisted of a pipe $\frac{7}{8}$ in. in diameter, 12.013 in. long effectively, open at one end which was inserted into a large stilling tank and terminated at the other end by an orifice plate containing a sharp-edged circular orifice, 0.250 in. in diameter and 0.093 in. thick. From author's summary.

2350. Parlett, L. P., Aerodynamic characteristics of a small-scale shrouded propeller at angles of attack from 0° to 90°, *NACA TN* 3547, 12 pp., Nov. 1955.

Tests have been performed to determine the effects of airspeed and angle of attack on the lift, drag, and pitching moment of a shrouded-propeller model, having a shroud length of about two-thirds of the propeller diameter, over an angle-of-attack range from 0° to 90°. Tests were made of the complete model with the propeller operating and also of the shroud alone with the propeller removed. The effect of inlet-lip cross-sectional radius on the static-thrust characteristics was also studied. From author's summary.

Thermodynamics

(See also Revs. 2219, 2288, 2313, 2315, 2316, 2320, 2323, 2326, 2327, 2334, 2340, 2366, 2376, 2385)

2351. Rossing, T. D., Amme, R. C., and Legvold, S., Heat capacity lag of gaseous mixtures, *NACA TN* 3558, 35 pp., Mar. 1956.

The velocity of sound in 14 heavy gases, all of them halogen derivatives of methane of the highest purity available, was determined at 300K as a function of the pressure at frequencies of 300 and 1000 kc/sec by use of an acoustic interferometer of the Pierce type. The results, plotted as a function of log (*sonic frequency/pressure*), show no evidence of the existence of multiple relaxation times, indicating that, once the vibrational mode of lowest frequency is excited, the energy passes readily into the other modes by virtue of the relatively strong intermodal coupling in these gases. The characteristic relaxation time of the lowest vibrational mode is calculated for each gas and tabulated. Authors conclude that the excitation and de-excitation of molecular vibrations in the gases tested are brought about principally by binary collisions, and depend upon the relative energy of approach of the colliding molecules rather than their relative velocity, as predicted by the Landau-Teller theory. R. Heller, USA

2352. Ziebland, H., and Burton, J. T. A., The thermal conductivity of liquid and gaseous oxygen, *Brit. J. appl. Phys.* **6**, 12, 416–420, Dec. 1955.

Using a vertical coaxial cylinder method, the thermal conductivity of liquid and gaseous oxygen was measured at temperatures between 80 and 200 K at pressures between 1 and 130 atm. The results are compared with those of other authors. From authors' summary

2353. Michels, A., Cox, J. A. M., Botzen, A., and Friedman, A. S., Contribution to the study of transport phenomena in gases at high densities, *J. appl. Phys.* **26**, 7, 843–845, July 1955.

Conductivity and viscosity for nitrogen and argon have been measured for temperature from 0–75 C and pressures up to 600 atm. Assumptions of Chapman-Enskog theory (inapplicable to dense gases) are shown to be inadequate to describe present experiments. Modifications to include intermolecular potential are outlined following the generalized pressure tensor expression of Hirschfelder et al. Present work has indicated a future program to investigate transport properties near but above critical point, including the intermediate region between gas and liquid state.

Reviewer believes program to be well conceived and to hold promise of valuable extensions to the theory of the gaseous state.

N. P. W. Moore, England

2354. Ribaud, G., and Manson, N., Physicochemical equilibrium and thermodynamic properties of gas mixtures at high temperatures (in French), *Publ. sci. tech. Min. Air France* no. 294, 111 pp. + 29 tables, 1954.

Authors present a review of the thermodynamic principles involved in determining the equilibrium composition and thermodynamic properties (internal energy, enthalpy, and entropy) of perfect gas mixtures. Numerous numerical examples are given, and practical methods of determining the equilibrium composition are discussed. Twenty-nine tables of various thermodynamic properties are listed, taken from Riband [AMR **6**, Rev. 3548], *Nat. Bur. Stands. Circ.* C461, and others. (Source of data is very poorly referenced.) Reviewer notes that dissociation energy of N_2 (Table 8) is incorrect. J. A. Fay, USA

2355. Rowlinson, J. S., The reduced equation of state, *Trans. Faraday Soc.* **51**, part 10, 1317–1326, Oct. 1955.

A table is given of the compressibility factor pV/RT of the inert gases as a function of the reduced temperature and the reduced density. It is shown that this table may be used to calculate the compressibility factor of substances which obey different reduced equations of state when the difference is due to the nonspherical shape of their molecules. The method is applicable to any substance whose vapor pressure is known up to the critical point and which is not strongly polar. The accuracy is generally about 1% at densities near the critical.

From author's summary

2356. Keyes, F. G., and Keenan, J. H., The present status of steam properties, ASME Ann. Meet., New York, Nov. 1954, Pap. 54-A-237, 22 pp.

This paper sketches the latitude of the Third International Steam Tables Conference of 1934. It was the intention of that conference that the limits of temperature and pressure, 550C (1032F) and 350 atm (5000 psia), respectively, would serve the needs of power producers for a long time. This hope seems not to have been realized. The need to extend our knowledge of water substance is deemed urgent. Contributions since 1934 are cited. The needs are advanced. The proposed limits are 800C (1500F) and 1000 atm (15,000 psia). The need is for enthalpy changes, *P-V-T* properties, Joule-Thomson coefficients, and the transport properties; specific heats, viscosity, and thermal conductivity, these latter two especially. Twelve figures are included to show the status of our knowledge in these areas.

C. R. Mischke, USA

2357. Malmquist, L., Tables for vapour pressure calculations, *Kyltekn. Tidskr.* no. 4, 51–55, Aug. 1955.

For a great many technically important substances a complete set of vapor-pressure-temperature data does not exist. In such cases, there is a need for a simple method of fitting the few data available or of calculating the pressure-temperature-relation from basic thermodynamical properties.

Author proposed earlier [AMR **7**, Rev. 4011] a pressure-temperature-relation which is generally valid. Completed with two constants depending on behavior at critical point and absolute zero, the relation seems to be applicable on all substances with fair accuracy.

In this paper, author tabulates the auxiliary functions. For purposes of checking and demonstration he applies the method to substances with well-known vapor pressure. He finds the accuracy for water to be 0.1% in the temperature range from −50C to the critical point, for Freon 13 (CF_3Cl) 0.4% from −139C to 25C, and for mercury 1% at 0C.

The relation seems to be a simple and accurate tool for describing experimental data as well as for calculating the vapor pressure in a wide temperature range from a few measurements.

A minor misprint appears in Eq. (4), where the limit value should be taken for the critical temperature, not for the absolute zero.

C. E. Lenngren, Sweden

2358. Holzmann, E. G., Dynamic analysis of chemical processes, *Trans. ASME* **78**, 2, 251–258, Feb. 1956.

A system for applying dynamic analysis to control of chemical processes is presented. Control of reaction in a fluid passing through a heat exchanger is described.

Criticisms expressed in discussion accompanying presentation are: (1) Absence of reference to literature that develops the method extensively; (2) assumption of heat-exchanger transfer function that does not recognize dead time; and (3) absence of experimental data to show adequacy of representation. J. C. Sanders, USA

2359. Devienne, F. M., Thermodynamic study of flow of rarefied air in the region of free molecular flow (in French), *Publ. sci. tech. Min. Air France* TN 55, 28 pp., 1955.

Experiments are described in which the steady-state temperature is measured on a small plate placed perpendicular to a free-molecule flow of dry air. Full details are given of the methods used and the results of

the numerous trials in the range of flow velocities U, such that $0.1 \leqslant U/v_s \leqslant 0.9$ and ambient pressure $0.2 \leqslant p \leqslant 0.7$ microns. V_s is the most probable Maxwellian speed. In every case, an elevation of the temperature of the plate is observed. The increment seems to be an increasing function of the flow velocity and the ambient pressure.

With the assumption that the gas is Maxwellian, author derives an expression for the temperature rise of the plate, making use of the work of Tsien [*J. aero. Sci.* **13**, p. 653, 1946] and Stalder et al [*NACA TN* 1682, 2244 and *J. aero. Sci.* **15**, p. 381, 1948]. Because of the doubtful assumptions employed—e.g., the gas cannot have an equilibrium, Maxwellian distribution because of the small number of intermolecular collisions, but must tend toward a unidirectional velocity distribution—author does not attempt to correlate predicted with measured temperature rise. Rather he assumes the theory exact and computes the ratio ϵ/a for each experiment. Here ϵ represents the emissivity and a the accommodation coefficient of the aluminum plate. Far from remaining constant, the ratio increases about seven-fold in the range of velocities used and shows no decided trend with pressure. He deduces from these data that the accommodation coefficient decreases strongly with increasing velocity.

F. D. Bennett, USA

Heat and Mass Transfer

(See also Revs. 2110, 2219, 2246, 2247, 2248, 2256, 2288, 2331, 2352, 2357, 2385, 2389, 2414, 2416)

2360. **Morris, A. L., Thermal rating of fluid-cooled transformer cores,** *Engineer, Lond.* **201**, 5221, 216–218, Feb. 1956.

Paper is a good up-to-date study of the maximum hot spot and surface temperatures of laminated and fluid-cooled transformer cores. The theory is based on Cockcroft's work, assuming uniform temperature for the cooling fluid. The results are particularly useful for transformers working at relatively high frequencies, such as 400 cps, 1000 cps, or higher. Reviewer believes that the paper is a valuable source of information for people working with the thermal problems of both standard and special transformers.

P. P. Biringer, Canada

2361. **Giulianini, A., Some observations on the heat conduction in isotropic or anisotropic media with conductivities being functions of temperature** (in Italian), *Termotecnica* **10**, 2, 63–68, Feb. 1956.

Putting $\Theta = 1/\lambda(t_0) \cdot \int_{t_0}^{t} \lambda(t)dt + t_0$, where thermal conductivity λ is a function of temperature t, the Fourier equation takes the form $a\Delta\Theta = \partial\Theta/\partial\tau$, identical to that as known in the case of λ independent of t (a being thermal diffusivity). In this manner, the problem is reduced to that with constant λ, which can be solved by some of the well-known approximative methods. An important technical problem of the heat flow through a plane layer is solved.

Z. Horák, Czechoslovakia

2362. **Philip, J. R., Numerical solution of equations of the diffusion type with diffusivity concentration-dependent,** *Trans. Faraday Soc.* **51**, 391, part 7, 885–892, July 1955.

Author considers solution of $(\partial\theta/\partial t) = (\partial/\partial x)\,[D(\partial\theta/\partial x)]$ in a semi-infinite solid with $\theta = \theta_n$, $t = 0$, $x > 0$; $\theta = \theta_0$, $x = 0$, $t \geq 0$. D is a single-valued function of θ. Equation is transformed via $\varphi = xt^{-1/2}$. The interval from θ_0 to θ_n is divided into n equally spaced steps. Application of finite differences to transformed equation leads to a practical iterative procedure for composing the solution. Treatment is illustrated with two numerical examples for which formal analytical solutions are available. Results are in good agreement and computations are presented in tables. Suppose $\partial k/\partial x$ is added to the left-hand side of above equation where k is a single-valued function of θ. Using same boundary and initial conditions as above, present procedure can be used as the initial step of a method for solution of equation just described. A paper on this subject is under preparation.

Y. L. Luke, USA

2363. **Datsev, A. B., On the two-dimensional Stefan problem** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **101**, 3, 441–444, 1955 (translated from Russian by M. D. Friedman, 572 California St., Newtonville, Mass., 7 pp.)

The phenomena of freezing and melting are of great importance in many branches of engineering (foundry practice, food-processing technology, chemistry of aerosols, etc.). The pertinent literature is extensive, yet cross-referencing between the various type of engineering applications, an important stimulus for more rapid progress, is seldom noted, and a tie-in with present mathematical tendencies is almost nonexistent.

Reviewer, with main interest in foundry operations, takes the liberty of enumerating papers he found most helpful in his work. "Rate of ice formation" by London and Seban, *Trans. ASME* p. 771, 1943, interprets the freezing process by the method of lumped parameters (see also, "Study of thermal diffusion equation with boundary conditions corresponding to solidification or melting of materials initially at fusion temperature" by Kreith and Romie, *Proc. phys. Soc.* p. 277, 1955; "Rate of solidification" by D. Cochran, Stanford Univ., ONR Rep. 24, 1955). "Practical heat transfer" by W. S. Pellini, *Trans. Amer. Foundrymen's Soc.* p. 603, 1953, correlates temperature measurements in solidifying castings with electrical analog work of V. Paschkis (see also the comprehensive book, "Solidification of castings" by R. W. Ruddle, London, 1950). "Melting and freezing" by B. Chalmers, *Trans. AIME* p. 519, 1954, surveys metallurgical aspects; particularly, segregation (see also "Redistribution of solute atoms during solidification of metals" by Tiller, Jackson, Rutter, Chalmers, *Acta Metall.*, p. 428, 1953). "Solidification of molten steel" by Lightfoot, *Proc. Lond. math. Soc.* p. 97, 1930, gives an alternate, illuminating derivation of Stefan's well-known solution (cf. Carslaw-Jaeger's "Conduction of heat in solids"; "Ingersoll-Zobell-Ingersoll's "Heat conduction") for the semiinfinite casting with temperature-independent properties, and also gives a valuable approximate solution for castings of finite lengths.

Most present-day mathematical papers concentrate on existence theorems and prescription of iteration methods which presumably furnish the answer to the problem in question provided a sufficiently large computer—and sufficiently large funds to run the computer—are available. The question of existence of a solution is by no means trivial; we are concerned with the diffusion equation (linear parabolic differential equation) for two adjacent media, having different thermal constants, separated by a traveling boundary (governed, for the one-dimensional problem, by an ordinary nonlinear differential equation), the initial temperature distribution—and location of the boundary—being given. For contemporary mathematical investigations of the one-dimensional case, see e.g., "Stefan-like problems" by Evans, Isaacson, MacDonald, *Quart. appl. Math.* p. 312, 1950, and the very comprehensive paper, "Existence and uniqueness of solution of Stefan-like problems" (in Italian) by G. Sestini, *Riv. Mat. Univ. Parma*, p. 3, 1952 (the finite slab problem), and p. 103 (the finite cylinder problem).

Paper under review considers two-dimensional generalization of freezing problem. Inside of a smooth closed curve l_0 (at time $t = 0$) temperature $u^{(2)}(x,y,o)$ of liquid, and outside of curve temperature $u^{(1)}(x,y,o)$ of solid (which extends to infinity) is prescribed. In the three-dimensional xyt space, one visualizes a surface L generated by the instantaneous freezing fronts l stacking up above curve l_0. Author regards path element Δs on surface L as result of vertical motion (l is constant, time is varied) and horizontal motion (t is constant, l is varied). He integrates the front propagation, ds/dt, equation over time element Δt, keeping the temperature gradients on interface constant; then, using the so-determined Δs, he solves for the temperatures, in the above-described two-step manner, from complicated integral equations (for whose establishment he refers to earlier work as well as to Russian texts on integral equations). He then repeats process, advancing another Δt step, etc. By making the time intervals Δt sufficiently small, author states that convergence to rigorous solution is assured. (Details are sketchy.)

G. Horvay, USA

2364. **Datsev, A. B., On the three-dimensional Stefan problem** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **101**, 4, 629–632, 1955 (translated from Russian by M. D. Friedman, 572 California St., Newtonville, Mass., 6 pp.)

Approach is similar to that described in preceding review. An initial surface of temperature zero is prescribed.

G. Horvay, USA

2365. **Wemelsfelder, P. J., Research concerning the caloric balance in a river during a frost period** (in Dutch), *Ingenieur* **68**, 8, B29–B35, Feb. 1956.

This paper deals with the caloric balance of rivers as a function of the radiation, the temperature of the air, the supply of ground water, and the energy of the fall. The water follows the temperature of the air coming up every day with 10% of the actual difference.

From author's summary

2366. Brokaw, R. S., Estimating thermal conductivities for nonpolar gas mixtures. Simple empirical method, *Indust. Engng. Chem.* **47,** 11, 2398–2400, Nov. 1955.

In heat-transfer problems involving gases, the thermal conductivities of gas mixtures are often required. Direct measurement may be difficult or impossible.

An empirical technique for estimating conductivities of mixtures of nonpolar gases is presented. Comparison with measured values from the literature shows an average error of 2.6% with a maximum error of 11.4%.

Mixture thermal conductivities may be estimated quickly; only the composition of the mixture and conductivities of component gases are required. Accuracy is comparable to that of the more complicated methods which have been proposed heretofore. From author's summary

Book—2367. Kraus, W., Measurement of temperature and velocity field in free convection [Messungen des Temperatur-und Geschwindigkeitsfeldes bei freier Konvektion], Karlsruhe, Verlag G. Braun, 1955, viii + 147 pp.

Book gives an excellent detailed account of experimental techniques and equipment used in the measurement of velocity and temperature fields in convection processes. Free convection is considered in particular.

After brief but clear introduction which includes discussions of historical and theoretical developments in heat convection, author treats such subjects as (1) test-model shapes, fabrication materials, and surfaces, (2) thermocouple construction, calibration, and installation, and (3) evaluation, application, and accuracy of results.

Fundamentals of schlieren and interferometric methods are presented, as are test set-ups and procedures; glass or quartz filament anemometers for velocity measurements are also discussed.

Numerous examples of the afore-mentioned techniques taken from various research works on free convection are presented. Many photographs, schematic and cross-sectional drawings, and graphs are distributed throughout the book and add to the clarity of the text. A table is included which summarizes in detail most of the outstanding experimental work in free convection.

Reviewer recommends book to all experimenters as well as to anyone interested in free convection. S. Ostrach, USA

2368. Vernotte, P., Study of natural convection (in French), *Publ. sci. tech. Min. Air. France* no. 288, 58 pp., 1953.

This essay summarizes the theoretical and experimental work carried out on the convection problem by M. Vernotte and his collaborators.

He recognizes the basic problem as one of interaction between temperature and velocity fields. Considering small amounts of heating, the temperature field is taken as a first approximation to be that associated with pure conduction, and an attempt is made to derive the velocity field from the steady-state equations of heating and motion. However, the series solution obtained by this method for a heated sphere diverges. Convection between parallel plates is discussed, and attention is drawn to the theoretical importance of nonlinear terms. Results from forced-convection experiments lead the author to the conclusion that the coefficient of convective heat transfer is proportional to the cube root of the characteristic velocity for small velocities, and the sixth root for large velocities. He justifies regarding pure conduction as the limit of convection in any system as the heating tends to zero.

On the experimental side, the author discusses the results of his experiments with small temperature differences, giving a formula for the coefficient of convective heat transfer as a function of the heating. He then discusses the effects of the shapes of convectors, and the factors determining the relative importance of convection and radiation.

Reviewer believes this monograph to be of considerable importance and interest and would like to bring it to the notice of all concerned with the convection problem in any of its forms. On the theoretical side, the attempt to establish the link between pure conduction and convection, although not completely successful, is obviously of fundamental importance. Perhaps the consideration of steady-state equations is too restrictive; the differential heating of a compressible fluid under gravity must create a vorticity distribution, which is continually redistributed. The problem should be further pursued along the lines indicated in this essay. R. P. Pearce, Scotland

2369. Hartnett, J. P., Experimental determination of the thermal entrance length for the flow of water and of oil in circular pipes, ASME Ann. Meet., New York, Nov. 1954. Pap. 54–A–184, 19 pp.

The thermal entry length (distance from the start of heating in a tube, necessary to establish a constant film coefficient) under conditions of constant heat release per unit length of tube was investigated for tap water and Freezene oil. The magnitude of the thermal entrance length was found to be dependent upon the hydrodynamic conditions at the entrance to the heat exchanger. For fully established flow at the position of initiation of heating, the thermal entrance length is 10–15 diameters and was found to be independent of the Prandtl number if such is greater than unity. In the transition region as the Reynolds number is increased, the thermal entrance length decreases from large values representative of laminar flow to a value approximating ten diameters. The evidence supporting the full hydraulic establishment of flow before commencement of heating is not conclusive. Twelve graphs are presented along with a large bibliography. C. R. Mischke, USA

2370. Reshotko, E., and Cohen, C. B., Heat transfer at the forward stagnation point of blunt bodies, *NACA TN* 3513, 17 pp., July 1955.

Laminar boundary-layer theory is applied to the flow in the vicinity of the forward stagnation point, based on the exact solutions of the laminar boundary-layer equation for external flows of the Falkner-Skan type with constant surface temperature, and with and without transpiration cooling. Previous solutions are reviewed and additional stagnation-point solutions (both two-dimensional and axially symmetric) are presented for Prandtl number of 0.7, with and without transpiration cooling.

The heat-transfer relations are given in terms of a heat-transfer parameter and the local external velocity gradient at the stagnation point.

Examples of the use of these heat-transfer relations are presented. R. J. Nickerson, USA

2371. Libby, P. A., and Visich, M., Jr., Laminar heat transfer in two-dimensional subsonic effusors, *J. aero. Sci.* **22,** 6, 425–430, June 1955.

The partial differential equations for the two-dimensional laminar compressible boundary layer of a perfect gas with Prandtl number of unity and obeying a Chapman type of dependence of viscosity on temperature, and with constant specific heat are solved for flow in an effusor. These equations were first reduced to integral equations by using the Dorodnitzin transformation, and the resulting integral equations were solved by an extension of von Karman's method, assuming fourth- and fifth-degree polynominals for representation of velocity and stagnation profiles, respectively. The results lead to rates of heat transfer along the contours of two different subsonic effusors, taking into account the variation of axial pressure gradient. The results were confirmed by exact numerical integration of the differential equations for the two contours. J. Kaye, USA

2372. Ostrach, S., Compressible laminar boundary layer and heat transfer for unsteady motions of a flat plate, *NACA TN* 3569, 26 pp., Nov. 1955.

Author analyzes the heat-transfer characteristics of the laminar compressible boundary layer over an isothermal, semi-infinite flat plate moving with a continuous, time-dependent, but otherwise arbitrary velocity. The differential equations of the boundary layer are solved in series to obtain first-order deviations from the quasi-steady velocity and temperature profiles.

Results show that, if the surface temperature is greater than the free stream temperature, positive acceleration causes the heat-transfer rate to decrease; if the surface temperature is less than the free-stream temperature, the heat-transfer rate can either increase or decrease, depending on Mach number and plate-to-stream temperature ratio. Results also indicate that, when the plate oscillates about a steady velocity, the local heat-transfer rate is out of phase with the plate velocity, but the phase angle depends significantly on frequency of oscillations, Mach number, and plate-to-stream temperature ratio.

This investigation is essentially an extension of the insulated-plate analysis of Moore [AMR **5**, Rev. 828] to include the effects of heat transfer. H. A. Stine, USA

2373. Jack, J. R., and Diaconis, N. S., Variation of boundary-layer transition with heat transfer on two bodies of revolution at a Mach number of 3.12, *NACA TN* 3562, 16 pp., Sept. 1955.

Reynolds number at which boundary layer became turbulent was determined experimentally as a function of wall-to-free-stream temperature ratio for models having a maximum surface roughness less than 16 microinches. Thin-skinned models were tested in a continuous-flow tunnel. For cooled-model tests, transition was indicated by a sudden increase in the time rate of change of skin temperature, whereas for heated-model tests, transition was detected from the heat-transfer coefficients.

At equilibrium conditions (wall temperature equal to recovery temperature), transition Reynolds number was found to be approximately two million for the cone-cylinder body. Transition Reynolds number increased continuously to 10.6 million as the temperature ratio was decreased to 1.4, and decreased continuously to 0.86 million as the temperature ratio was increased to 4.2.

For a given temperature ratio, the transition Reynolds number for the parabolic-nosed body was found to be approximately twice that for the cone-cylinder body, demonstrating the effect of a favorable pressure gradient.

E. L. Knuth, USA

2374. Shapiro, N. M., Effects of pressure gradient and heat transfer on the stability of the compressible laminar boundary layer, *J. aero. Sci.* **23,** 1, 81–83, Jan. 1956.

Calculations of the minimum critical Reynolds numbers for stability of compressible, laminar boundary for thin airfoils with heat transfer are presented for a range $1.5 < M < 3$ for temperature ratios $1.0 < T_w/T_e < 4$. Calculations were made using flow characteristics calculated by Low [*NACA TN* 3028; AMR **7**, Rev. 1191] and the two-dimensional stability calculations of Lees [*NACA TR* 876; AMR **6**, Rev. 485]. The results are presented graphically for both accelerating and decelerating flows and for heating and cooling. In confirmation of other similar studies, the results show that effects of heating or cooling on boundary-layer stability are much stronger than the small pressure gradient effects. The data also show that there is a destabilizing effect with increasing Mach number for the case of an adiabatic wall, in agreement with earlier investigators; however, when heating occurs, the reverse is true—an increase in Mach number produces a slight stabilizing effect, especially for adverse pressure gradients.

R. M. Drake, Jr., USA

2375. Sandborn, V. A., and Laurence, J. C., Heat loss from yawed hot wires at subsonic Mach numbers, *NACA TN* 3563, 44 pp., Sept. 1955.

Heat-loss data are presented for several wires of diameters in common use in hot-wire anemometry at angles of yaw at subsonic Mach numbers. Contrary to some existing data, it was found that the Reynolds number of the flow normal to the wire does not correlate the data. A reasonably good correlation was found with a more complicated expression.

A. M. Kuethe, USA

2376. Forstat, H., and Reynolds, C. A., Compressibility and heat transfer of helium II, *Phys. Rev.* (2) **101,** 2, 513–518, Jan. 1956.

It has been demonstrated that the thermomechanical effect operates in a closed system of helium II. This effect has been used to measure the compressibility of helium II. The results agree relatively well with the results of other investigators who used other methods. The agreement indicates that the method used, a packed column of rouge in a closed system, is a good one for obtaining the full thermomechanical effect. The heat transfer of helium II in the rouge column has been measured. The behavior found is, in general, similar to that found for the heat transfer through a slit between two optically polished surfaces. Evidence was found for a maximum in the heat transfer close to, but below, the λ point.

From authors' summary

2377. Deissler, R. G., Analysis of turbulent heat transfer, mass transfer, and friction in smooth tubes at high Prandtl and Schmidt numbers, *NACA Rep.* 1210, 14 pp., 1955.

See AMR **7,** Rev. 3721.

2378. Estoque, M. A., The spectrum of large-scale turbulent transfer of momentum and heat, *Tellus* **7,** 2, 177–185, May 1955.

Certain meteorological facts, together with requirements of global momentum and energy balances, lead to the conclusion that there must be continuous net transport of momentum and energy in a single direction throughout a substantial portion of the atmosphere. Author examines the theory that horizontal mixing processes are the mechanism which effects these transfers. The approach is to express fluctuations in air velocity and temperature over some extended period of time as Fourier integrals. The Fourier transform yields a spectrum of turbulent transfer. This spectrum gives an estimate of the relative contribution of disturbances of varying periods to momentum and energy transfers. Author treats a set of data taken at one pressure surface over a year's time. The results indicate that the most important contributions to atmospheric momentum and energy transfers are made by disturbances with periods of less than ten days. Author discusses the weaknesses of the set of data used and makes recommendations for extension of this work.

T. J. Connolly, USA

2379. Deissler, R. G., and Loeffler, A. L., Jr., Turbulent flow and heat transfer on a flat plate at high Mach numbers with variable fluid properties, ASME Ann. Meet., Chicago, Ill., Nov. 1955. Pap. 55–A–133, 29 pp. + 16 figs.

Senior author's method of solving turbulent boundary-layer problems is extended to present general case. The problem difficulties hold in spite of drastic simplification to integral equations solvable by somewhat laborious iteration techniques. Two adjustable constants can be selected by fitting low-velocity pipe turbulence velocity data. Several of the most serious (and certainly incorrect) assumptions are shown by extensive calculations to have little or no effect on the final results.

Authors thus get a completely prescribed, if long and tedious, calculation procedure for velocity and temperature distribution and heat-transfer and friction coefficients which check well with the meager experimental results available.

For some years there has been a number of more or less practical, more or less accurate calculation techniques for describing analytically turbulent boundary layers. Authors have shown good results from yet another procedure. Probably none of the methods are wholly right or wholly wrong. None are very simple and it is difficult to say which is best. Authors' method is as well founded and gives accurate results.

H. W. Emmons, USA

2380. Gershuni, G. Z., On the stability of plane convective motion of fluids (in Russian), *Zh. tekh. Fiz.* **25,** 2, 351–357, Feb. 1955.

Differential equations of motion and of temperature variation in a viscous incompressible fluid can be written in nondimensional form and contain the Grashof and Prandtl number [Landau-Lifshitz, "The mechanics of continuous media," AMR **8,** Rev. 2960]. Solutions for the velocity and temperature distribution in the case of laminar flow between two parallel plates with an arbitrary inclination to the vertical line can then be found readily, if the flow is assumed stationary. The stability of such flows is examined in the usual manner and differential equations for the amplitudes of velocity and temperature fluctuations are derived. Approximate solutions of these equations and the corresponding critical values for the beginning of convection are found by the Galerkin method, using two different forms of expressions for the stream function and temperature distribution of the fluctuations. The simpler form gives values which can be regarded as fairly correct if the heated plate is on the lower side of the system; the second form of approximations gives critical values which can be used if the heated plate is on the upper side. In the first case, the instability of laminar flow is very little affected by the velocity v_0 of the mean flow; in the second case, the influence of v_0 on stability is very large.

A. Kuhelj, Yugoslavia

2381. Eckert, E. R. G., Livingood, J. N. B., and Prasse, E. I., One-dimensional calculation of flow in a rotating passage with ejection through a porous wall, *NACA TN* 3408, 29 pp., Mar. 1955.

Authors present an analytical method for determining the local permeability or the local flow distribution necessary for proper transpiration cooling of gas turbine blading. The analysis is derived by using Newton's second law of motion and the continuity equation in a one-dimensional flow for the blade coolant passages.

Reviewer believes paper is significant because it indicates compromises which may be required between prescribed wall temperature and more readily obtainable permeability or wall-thickness distribution for strength considerations.

Authors state: "For prescribed coolant flow ejection rates necessary to maintain a constant porous wall temperature, considerable reduction

in wall permeability from passage entrance to passage tip is required. For prescribed locally constant permeability, the mass flow ejection rate increases from blade root to blade tip; however, the relative increase became smaller when the inlet pressure of the coolant was increased."

B. L. Buteau, USA

2382. Savic, P., and Boult, G. T., The fluid flow associated with the impact of liquid drops with solid surfaces, *Nat. Res. Counc. Canad. mech. Engng.* (Gas Dynamic Div.) Rep. MT-26, 29 pp. + 15 figs., May 1955.

A theory is presented of the fluid flow associated with the impact of liquid drops with a solid surface. The shape of the spreading drop is calculated as well as the pressure distribution over the impact plane. Experiments carried out with high-speed spark camera bears out the main features predicted by theory.

Experiments with water drops impinging on a hot surface show that the general outline of the pressure distribution is also confirmed. Photographs of molten wax drops impinging on a cold surface show a marked increase in the splashing, a phenomenon for which an explanation is attempted by considerations of the interaction of fluid flow and heat transfer.

From the authors' summary by Myron Tribus, USA

2383. Giedt, W. H., The determination of transient temperatures and heat transfer at a gas-metal interface applied to a 40-mm gun barrel, *Jet Propulsion* **25**, 4, 158–162, Apr. 1955.

A special thermocouple is described which measures transient temperatures at a plane very close to the bore of a 40-mm gun barrel. This thermocouple is an application of a design developed in Germany around 1940 by Hackemann. Author and his assistants have successfully fabricated the thermocouple in quantity and have proven its usefulness in temperature and heat-transfer studies of gun barrels. A limitation of the thermocouple is that the distance from the exposed surface to the thermal junction is not precisely known and is greater than the corresponding dimension of the Hackemann thermocouple, approximately 200 microinches instead of 80. Reviewer believes that a minimum distance as well as the precise knowledge of this distance is important, as the region of the barrel adjacent to the bore is subjected to extremely large and variable temperature gradients during rapid temperature changes at the bore. Author bases his heat-transfer rate calculations on the temperature-time variation measured by the thermocouple. Lack of knowledge as to the precise location of the thermal junction results in errors in calculating the rate of heat transfer at the surface, especially during the time of maximum temperature gradients from the bore. The rate curve at the bore probably has an extremely high and narrow peak in the 40-mm gun; consequently, inability to predict this accurately would not seriously change the total heat-transfer curve.

Reviewer believes that the use of the solution for the temperature at the interface of two semiinfinite solids suddenly brought together is not a clear argument for evaluating the second term of the equation for the rate of heat transfer. This solution requires the temperature at the interface to be constant, a condition not existing at the interface of the gas and barrel during the firing cycle. The observed temperature variation is implied by the author to be caused by "subsequent convection heat transfer by the propellant gases." The division of the heat transfer into a conduction and a convection mechanism is not developed in the paper. To solve the equation of the rate of heat transfer for the probable plane at which the thermal junction is located, author eliminates the second term of the rate equation by first allowing the plane of the thermal junction to be at the surface for the first part of this term and then moving it away from the heated region of the surface for the second part. Perhaps in the physical situation, the contribution of the second term is negligible and can be eliminated. Reference to the solution of the interface temperature of semiinfinite solids suddenly brought in contact then would not be necessary.

The thermal properties used in the heat-transfer equations are those of the infinitesimally thin slab of metal at the plane being considered. In the interest of improved accuracy, the values of these properties used should be those corresponding to some elevated temperature, possibly the average surface temperature during the interval of time considered. As indicated in the author's Fig. 6, this would be approximately 800 C for the first station. The thermal properties of the gun steel used are appreciably different at this temperature than at ambient temperatures. The square root of these values is used in the equations so that the variations due to high temperatures are not serious to the over-all accuracy of the calculations.

The comparison of the author's work to theoretical work by Nordheim, et al, shows interesting correlation of the same order of magnitude. The work reported by this paper provides a valuable contribution to the heat-transfer studies in research concerning gun barrels and propellant-charge development programs, regardless of the criticism of the above items.

C. E. Moeller, USA

2384. Stickney, T. M., Recovery and time-response characteristics of six thermocouple in subsonic and supersonic flow, *NACA TN* 3455, 25 pp., July 1955.

Author has collected considerable experimental data with six thermocouple probes to determine their recovery factors and time constants in room total temperature. Average recovery-factor curves over the Mach number ranges of 0.2 to 2.2 are presented. At Mach number of 2.2 for a pressure of one atmosphere, the recovery factors of three unshielded probes are approximately 0.95; for the three shielded probes they are 0.988 and above. The shielded probes have recovery factors which have much greater sensitivity to variations from the reference pressure than those of the unshielded probes. Sensitivity to yaw and pitch of the various probes is presented. Author shows that, for thermocouple probes to be used in supersonic flow, the thermal junction should not be crossed by strong compression shocks generated by the probe or the thermocouple support. A sudden decrease in the recovery factor occurs when the thermal junction breaks through the bow wave.

The observed time constants of the six probes range from 0.16 to 0.9 sec. The time constants of the shielded probes are at the upper limit. The equipment used to evaluate the time constants was simple; however, author does not indicate the temperature function obtained with the equipment to similate a step temperature change at the thermal junction of the test probe. The deviation from a step function could possibly effect the values of the time constant, especially of the probes with low time constants.

Reviewer believes that inclusion of typical experimental curves would make this paper a more useful source of information. However, it is well done and does represent valuable work in the field of thermocouple probe design.

C. E. Moeller, USA

Combustion

(See also Revs. 2122, 2288, 2340)

Book—2385. Lewis, B., Pease, R. N., and Taylor, H. S., editors, Combustion processes, (High speed aerodynamics and jet propulsion, Vol. II.), Princeton, Princeton University Press, 1956, xv + 662 pp. $12.50.

This is the second of a twelve-volume series on high-speed aerodynamics and jet propulsion published by cooperation of the Air Research and Development Command of the Department of the Air Force, the Chief of Ordnance of the Department of the Army, the Office of Naval Research, and various bureaus of the Department of the Navy. Chief editor for this volume is Bernard Lewis, but he notes the actual duties have been carried out largely by Professor Irwin Glassman of Princeton University.

The book will be an effective library addition for any group dealing with combustion research. The summaries of various aspects of the field are, in general, well written and emphasize advanced and recent aspects of the work as well as fundamentals. The bibliographies are selective rather than comprehensive, but are well chosen.

Part I. Thermodynamics of combustion, B. Lewis, Ed. This consists of three parts. The first is on "High-temperature equilibrium," by Jas. M. Carter and David Altman. It gives a brief but effective summary of problems of determination of equilibrium compositions and thermodynamic properties, heat release, and flame temperatures, and the effects of gas imperfections. The second part, by the same authors, deals with "Expansion processes," and covers flow processes of various types, adiabatic and nonadiabatic, etc., the important thermodynamic relations for these, and determination of performance parameters such as exhaust velocities and specific impulse. Criteria for maintaining equilibrium and the effects of incomplete reactions and reassociation reactions are discussed. The last section is devoted to two-phase systems and flow with phase changes. The third part is on "Computational methods in

combustion calculations," by Stuart R. Brinkley, Jr. This is more highly specialized than the others. It is essentially an extension of the first part to more detailed consideration of methods of calculating equilibrium compositions and thermodynamic properties, with brief reference to use of punched-card equipment or other automatic computers.

Part II. Chemical kinetics of combustion, H. S. Taylor and R. N. Pease, Eds. This part has an initial section on "Fundamentals of chemical kinetics," by Hugh S. Taylor. The classical definitions, concepts, and methods of gas-phase kinetics are covered, including the collision and absolute rate theories, the concept of activation energy, chain mechanisms, and explosions. Wall reactions and surface reactions are also included. The final portion deals with fast reactions, particularly experimental methods of approach and problems of nonequilibrium and nonequipartition conditions. The second section is on "Kinetics of several oxidation reactions," by Robt. N. Pease. The classical oxidation systems, with hydrogen, carbon monoxide, and paraffin hydrocarbons, are reviewed, with clear emphasis upon the numerous uncertainties still existing in our knowledge of the mechanisms involved. Brief consideration is also given to certain other systems—not necessarily oxidation but all highly exothermic ones—such as the decomposition of diborane and nitromethane, the hydrogen-fluorine reaction, and the recombination of hydrogen atoms.

R. C. Anderson, USA

2386. **Ladanyi, D. J., and Miller, R. O., Two methods for measuring ignition delays of self-igniting rocket propellant combinations,** *Jet Propulsion* **26**, 3, 157–163, Mar. 1956.

One method consists of a modified open-cup apparatus where mixing is obtained by crushing a fuel-filled ampule under the surface of oxidant. The other method uses a transparent rocket engine (50-lb thrust). The first method shows a greater dependence of results on the viscosity of the propellants; it is, however, suitable and convenient for rapid screening of propellant combinations and for determining the effect of low temperatures on ignition delay, provided the viscosity is not greater than about 20 centistokes. The small-scale engine apparatus is able to give information about the effect of ambient pressure, combustion-chamber geometry, flow rates, and fuel-oxidant ratios.

A. Van Tiggelen, Belgium

2387. **DeZubay, E. A., A comparative investigation of a homogeneous combustion chamber with a two-stage combustion chamber,** *Jet Propulsion* **26**, 2, 77–80, 97, Feb. 1956.

A theoretical analysis is made of the ultimate heat release attainable in a combustion chamber, assuming instantaneous mixing and an Arrhenius-type reaction-rate law. Particular attention is directed to the case where one wishes to burn fuel with twice the stoichiometric portion of air. Rather than use a single chamber of volume V, it is shown to be better to burn the fuel with a portion of the air in a chamber of volume $V/2$, and then mix the partially-burned combustion products with the remaining air and burn further in a second chamber of volume $V/2$. It is demonstrated that such a two-stage reactor permits higher throughputs at a given over-all efficiency.

R. Friedman, USA

2388. **Marklund, T., Combustion problems in solid propellant rockets** (in Swedish), *Artill. Tidsk.* **84**, 5, 167–190, 1955.

A deeper understanding of the internal ballistics and combustion problems in the solid-propellant rocket is an important ordnance interest.

Author sums up the theories and problems in internal ballistics, the experimental technique for determination of the burning velocity with special references to the Research Institute of National Defence, Sweden, and the main feature of the burning theories of Muraour, Boys, Corner, Sänger, and Rice-Ginell.

He stresses the importance of having reliable, true theories, of which he regards the Rice-Ginell theory to be the most relevant one for rockets. He is, however, likely to consider it more worth-while in the present state of knowledge to carry out additional basic experimental work.

C. E. Lenngren, Sweden

2389. **Winter, E. F., Heat transfer conditions at the flame tube walls of an aero gas turbine combustion chamber,** *Fuel* **34**, 4, 409–428, Oct. 1955.

Author considers the effect of a ceramic coating on the heat transfer from a gas-turbine combustor can. A group of 15 unique "patch" thermocouples were used to measure combustor metal temperature at arbitrarily selected locations on the flame tube. Calculations of heat transfer by conventional methods based on observed metal temperatures, on experimentally determined emissivity of the surfaces, on calculated emissivity of the combustion gases using conventional PL technique, and on assumed gas temperatures showed: (1) An appreciable change in absorptivity of the flame tube causes a small change in thermal conditions at the flame-tube wall; (2) with a bare metal flame tube, 61% of the heat transferred from the flame to the metal was by radiation; (3) with a ceramic-coated flame tube, 64% of the heat transferred to the flame tube was by radiation; (4) that heat transfer to the flame tube is more radiant than convective; and (5) ceramic coatings had little effect on heat transfer under the conditions of this experiment.

W. T. Reid, USA

Acoustics

(See also Revs. 2349, 2351)

2390. **Brillouin, J., Reflection and refraction of acoustic waves by shock waves** (in French), *Acustica* **5**, 3, 149–163, 1955.

Sound waves consistent with a uniform shock wave and a plane progressive uniform incident wave are considered, assuming medium to be viscous and heat conducting. In compressed region, there exist waves of two types, acoustical and "thermal" (the latter having a nature analogous to contact discontinuities, i.e., variable temperature and density, constant pressure, and traveling with the velocity of the gas). Reflected wave is analogous to incident wave. Refracted wave may be analogous to incident wave (with less or greater amplitude) or take the form of a wave attached to the front of the shock while sliding parallel to it ("onde d'accompagnement").

G. Moretti, Argentina

2391. **Werth, G. C., and Delsasso, L. P., Attenuation of repeated shock waves in tubes,** *J. acoust. Soc. Amer.* **26**, 1, 59–64, Jan. 1954.

As very intense sound waves propagate, the wave shape changes into one of saw-tooth form producing abrupt rises in pressure called shock fronts. This wave-form distortion into so-called repeated shock waves is caused by the nonlinearity of the medium. The objective of this study has been to obtain experimental facts relative to the propagation of repeated shock waves in tubes and to compare these with existing theory. An intense sound source was constructed and appropriately coupled to a series of measuring tubes. Observations were made on the velocity and attenuation of fully developed shock waves for a variety of gases, for pressure amplitudes as great as 0.25 atmos, and for a fundamental frequency range of from 400 to 1200 cps.

The data were compared with previous theoretical work, particularly that of Professor Rudnick. Agreement was found in the general aspects of the theory; the exact magnitude of the effect remains to be explained. This discrepancy between theory and experiment may be resolved by considering in greater detail the absorptive processes involved.

From authors' summary

2392. **Brekhovskikh, L. M., and Ivanov, I. D., On one special form of damping in wave propagation in laminar inhomogeneous media** (in Russian), Acoustics Inst., Akad. Nauk SSSR, Nov. 1954 (translated from Russian by M. D. Friedman, 572 California St., Newtonville, Mass., 12 pp.)

From solutions by first author in previous papers, solution of wave equation is constructed for a two-layer model: bottom layer is homogeneous; in upper layer, wave velocity decreases linearly with distance from interface. The greater this rate of decrease, the more energy is "drawn off" through refraction into the upper layer, and therefore the greater the departure of attenuation in the homogeneous layer from the inverse square law. Some numerical values for this damping are given.

M. Wurtele, USA

2393. **Rakhmatulin, Kh. A., Solution of problems for the reflection of sound waves from a rigid surface with a deformable part** (in Russian), *Prikl. Mat. Mekh.* **18**, 5, 573–584, Sept.-Oct. 1954.

A plane sound wave front of constant intensity is normally incident on a plane containing an infinitely long movable strip ("piston") of

width $2l$ and mass m per unit length. Equations for force on the piston are developed; equation for piston motion is set up, whence it is shown that there is no virtual mass associated with the moving piston. In concluding paragraph, author indicates methods developed may be applied to several such pistons or to a deformable plate whose deflection shape may be expressed as a power series in the spatial coordinate. There are numerous typographical errors and omissions in the equations. W. W. Soroka, USA

2394. Lyamshev, L. M., Reflection of sound by a thin plate in water (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **99**, 5, 719–721, 1954 (translated from Russian by M. D. Friedman, 572 California St., Newtonville, Mass., 4 pp.)

Observations using high-frequency pulse technique are described briefly. Reflections in a direction anti-parallel to the obliquely incident ray are found at two critical angles, corresponding, respectively, to flexural and to compressional waves in the plate. The latter case is presented as new; related transmission data [e.g., AMR **4**, Rev. 4643; **6**, Rev. 1399] are not cited or discussed. P. Rudnick, USA

2395. Isakovich, M. A., Dispersion of waves from a statistically rough surface (in Russian), *Zh. eksp. teor. Fiz.* **23**, 3 (9), 305–315, 1952 (translated from Russian by M. D. Friedman, 572 California St., Newtonville, Mass., 21 pp.)

Author refers to the Brekhovskikh's theory [AMR **9**, Rev. 1290] and presents a series of concrete cases of the diffraction of sound and electromagnetic waves dispersed from a rough surface with roughness that is large compared with the wave length. The plane wave is assumed to be incident to the surface and the field dispersion is observed in the Fraunhofer zone. Problem is solved by Kirchhoff's approximation, under the assumption that there is no "shading" of one part of the surface by another and secondary dispersion is eliminated. Basic computation is carried out for the acoustic case, and it is shown that transition to electromagnetic waves offers no difficulties.

Mathematical derivations are accompanied by 6 diagrams. References are made to basic theories and previous research by Rayleigh, Mandelshtam, Andronov and Leontovich, Gans, Brekhovskikh, Antokolski, Gnedenko and Stratton. J. J. Polivka, USA

2396. Zink, H., Noise investigations in gears (in German), *ZVDI* **98**, 8, 297–303, Mar. 1956.

2397. Thomas, N., On the production of sound by jets, *J. acoust. Soc. Amer.* **27**, 3, 446–448, May 1955.

2398. Anderson, A. B. C., A jet-tone orifice number for orifices of small thickness-diameter ratio, *J. acoust. Soc. Amer.* **26**, 1, 21–25, Jan. 1954.

The dependence of a jet-tone orifice number $tf/(\Delta p/\rho)^{1/2}$ on Reynolds number $[\rho t(\Delta p/\rho)^{1/2}]/\mu$ is shown for thin sharp-edged circular orifices whose thickness and diameter both vary from approximately $\frac{1}{8}$ to $\frac{3}{8}$ in., where t is thickness of orifice plate, f frequency, Δp pressure difference across orifice, ρ density, and μ viscosity of gas. Each jet-tone, in general, is composed of harmonics (fundamental and over-tones) as well as subharmonics (tones whose frequencies are less than the fundamental). The subharmonics are relatively unsteady in amplitude compared to the harmonics and may at times have a greater amplitude. The jet-tones at low Reynolds numbers appear relatively free of noise background. In general, as Reynolds number is increased to high values, the noise background at first engulfs the subharmonics, then the harmonics. The fundamental is the last to remain, finally disappearing in the noise background. From author's summary

Ballistics, Detonics (Explosions)

(See also Revs. 2122, 2198, 2388)

Soil Mechanics, Seepage

(See also Revs. 2156, 2184, 2185, 2188, 2258)

BOOK—2399. Karol, R. H., Engineering properties of soils, New York, Prentice-Hall, Inc., 1955, xii + 82 pp. + data sheets. $3.50 (Paperbound).

Book describes techniques of laboratory soil testing. Field testing not included. The following laboratory tests on soils are dealt with: water content, specific gravity, void ratio and porosity, mechanical analysis, Atterberg limits, classification, permeability, capillarity, seepage, consolidation, shearing strength, and water content-density relationships. Data sheets for recording laboratory data are given in the second half of the volume.

This is another one of many books dealing with soil testing; the presentation of tests is simple and emphasizes rather teachability than science. No references from periodicals are given and references end with the beginning of the year 1951; new books (e.g., T. W. Lambe, AMR **4**, Rev. 4335) are not mentioned. Atterberg limits are printed as Atterburg limits. Z. Bažant, Jr., Czechoslovakia

2400. Barrett, M., and Rose, W., Programming reservoir problems on the electric analyzer, *J. Petr. Technol.* **8**, 3, 57–59 (Tech. Note 327), Mar. 1956.

2401. Terletskaia, M. N., Determination of permeability of soils not carrying ground water (in Russian), *Gidrotekh. Stroit.* **23**, 2, 37–39, 1954.

Author presents a new formula evaluating the permeability of strata located above the water table on the basis of the quantity of water that percolates out of drill holes. The formula was deduced from the results of laboratory tests. It is valid in the cases when the ratio (α) between the water column height (h) in and the diameter (d) of the hole is less than 25. (Cases with $\alpha > 25$ were treated previously by V. M. Nasberg.) According to this formula, the coefficient of permeability is $k = (Q/h'^2)f(\alpha)$, Q rate of flow at the steady state, $\alpha = h'/d$, $h' = h + 0.3\,h_k$, h_k capillary height. The $f(\alpha)$ values are given in a diagram.

L. Šuklje, Yugoslavia

2402. Meyerhof, G. G., Influence of roughness of base and groundwater conditions on the ultimate bearing capacity of foundations, *Géotechnique, Lond.* **5**, 3, 227–242, Sept. 1955.

Contemporary theories concerned with the behavior of strip footings at the ultimate load are reviewed. New analysis work dealing with influences of base roughness and groundwater conditions is presented. The findings are compared with results of load tests conducted on model footings. The bearing capacity of shallow footings (i.e., structrues where the foundation depth divided by its width ≤ 1) is reported to increase with roughness of base. The effect has been found to decrease rapidly with foundation depth. Relations between bearing capacity and base friction on a dense sand soil are graphically portrayed.

Groundwater conditions surveyed include full and partial submergence. Theoretical bearing capacity increases almost linearly with the depth of the water table to a maximum which remains sensibly constant for depths greater than twice the foundation width. For upward groundwater flow the bearing capacity reduces linearly with increasing average hydraulic gradient; divergence at large heads was traceable to local piping conditions around the footing base.

Reviewer suggests paper contains important data derived from a novel combination of footing bearing pressure theory. T. L. Speer, USA

2403. Peter, Y., The rational design of groundwater wells, *Civ. Engng. Lond.* **50**, 584, 186–189, Feb. 1955.

From the knowledge of the geological and hydrological conditions of the catchment area and the information obtained from single well-pumping tests without extra observation holes and with one maximum amount of flow only, author presents the method in use in Israel for the design of groundwater wells and the selection of the safe yield.

A. J. L. Bolognesi, Argentina

2404. Frohlich, O. K., Criticisms of the most used method for the calculation of safety of slopes against sliding (in German), *Öst. Ing.-Arch.* **9**, 2/3, 106–118, 1955.

Author discusses the "indirect" procedures after W. Fellenius, H. Krey and D. W. Taylor for computing the factor of safety of an earthy mass against sliding along the arc of a circle. He shows that the definitions of safety by the rules of W. Fellenius and J. Ohde are valid for the slip circle method only as approximations and gives a soil-statically correct definition of safety. For plane slopes with surface following horizontal ground and for toe circles he gives a new

diagram of envelopes for the relations between the inclination of slope, height H, volume weight γ, cohesion c, angle of internal friction φ, using well-known relations of other authors. By the application of this diagram he obtains the factor of safety against sliding, making use of the "rules" as well as of the correct definition. In many cases the design engineer will like to employ this simple and quick method for criticizing the risk of sliding, especially because the application is also possible if hydrostatic pressure or flow pressures exist.

G. Brandes, Germany

2405. Ohde, J., Calculation of stability of slopes of earth dams (in German), *Bautechnik- Arch.* **8**, 15–23, 1952.

Paper duplicates theory from *Bautechnik* **26**, 5, p. 129; 6, p. 163, 1949, giving methods for calculation of stability in normally consolidated and preconsolidated clays with regard to difference in consolidation and swelling characteristics (cf. Skempton's λ-theory).

H. Lundgren, Denmark

2406. Chamecki, S., Structural rigidity in calculating settlements, *Proc. Amer. Soc. civ. Engrs.* **81**, SM1 (*J. Soil Mech. Found. Div.*), Pap. 865, 19 pp., Jan. 1956.

Author computes the readjustment of loads from column to column on the basis of relative deflections (or settlements) of adjacent footings, and coefficients of load transference developed from the structural frame. New settlements are then computed from the readjusted loads and the process of approximation continues. Usually, this procedure is considered quite tedious and the results of little consequence, and, therefore, ignored in many settlement computations; however, the author has presented a straightforward method and indicated several short cuts which simplify the procedure.

To indicate procedure and show the effect of this "refinement," author has taken the example of a 3-story continuous frame placed over the classical soft clay layer (4.0 m thick) with center at 6.0-m depth. Settlement corrections for the rigidity of the structure result in reductions of maximum settlement by 11%, maximum differential settlement by 50%, and differential settlement between adjacent columns by 33%. These values may or may not be of significance to the soil engineer, depending upon the purpose for which the computations are made. For a given site and structure they are likely to be of considerable significance to the structural engineer in the evaluation of secondary stresses. No computations of this sort should be considered typical because of the infinite variety of structural arrangements and soil conditions.

A sidelight to this study of settlements of interest to the soil engineer is that, in the above example, the unit pressure beneath corner columns was increased nearly 50% by consideration of structural rigidity.

P. P. Brown, USA

2407. Cheek, R. E., and Menzie, D. E., Fluid mapper model studies of mobility ratio, *J. Petr. Technol.* **7**, 11, 49–52, Nov. 1955.

Authors have done excellent work in adapting fluid mappers to determination of areal sweepout efficiency for different mobility ratios. Fluid mappers were developed primarily to serve as models for steady-state situations, but this application extends them to simulate an unsteady state in oil recovery work.

As authors suggest, model may permit a more accurate analysis of economics of projects by dealing with irregular well patterns, or erratic fluid fronts due to equipment failure or changes in operating practices.

A. D. Moore, USA

2408. Vargas, M., da Costa Nunes, A. J., de Carvalho Lopes, J., Continentino, L., and Federico, D., The rupture of the Pampulha dam (in Portuguese), *Inst. Pesq. Tecnol. São Paulo Publ.* no. 529, 109 pp., 1955.

2409. Jumikis, A. R., Rupture surfaces in sand under oblique loads, *Proc. Amer. Soc. civ. Engrs.* **82**, SM1 (*J. Soil Mech. Found. Div.*), Pap. 861, 26 pp., Jan. 1956.

Very interesting experiments made in 1939–1942 at the Geotechnical Laboratory of the Technische Hochschule of Wien, Austria are reported. Scope was to determine the shape of rupture surface. Model was placed in a steel box with glass walls filled with dry typical Danube sand of known characteristics and most of it in the range of fine sand. To detect the rupture surface, layers of sand alternately natural and black-stained were tamped. Rupture was sudden and fault line was very well indicated by the colored layers, which were broken and displaced. Author was able to observe the shape of surfaces for both oblique and eccentric loads, which was that of a logarithmic spiral. Departure from theoretical curve was very small. Knowledge of the shape of rupture wedge enables the designer to determine the bearing capacity of a homogeneous sand soil or to compute the depth of foundation.

A. Balloffet, USA

2410. Li, C. Y., Basic concepts on the compaction of soil, *Proc. Amer. Soc. civ. Engrs.* **82**, SM1 (*J. Soil Mech. Found. Div.*), Pap. 862, 20 pp., Jan. 1956.

The optimum roller pressure is sufficient to cause local failure without causing complete failure. Since soil strength increases with compaction, maximum efficiency results from stage compaction or progressively increasing roller pressure. For constant unit pressure, larger contact areas permit thicker lifts.

E. S. Barber, USA

2411. Anonymous, Effect of size of feet on sheepsfoot roller, (Soil Compaction Investigation Report no. 6), *Wwys Exp. Sta. tech. Memo.* 3-271, iii + 29 pp., 4 tables, 15 photos., 26 plates, June 1954.

2412. Descans, L., Contribution to the calculation of sheet piles, Part I (in French), *Ann. Trav. publics Belg.* **107**, 2, 173–254, Apr. 1954.

This is first part of a study in which a theoretical basis is given for technical advice proposed in Anvers Congress (1954). Paper deals with calculation of anchored sheet pile walls. Active pressure of earth is evaluated in detail for a vertical isolated load, for which Boussinesq method proves to be unsuitable. In calculating water pressure, floods and tides are taken in account. Free-earth-support methods are not accepted; moments are computed with Blum method (fixed-earth-support). Factor of safety is not established according to traditional methods. Structure is dimensioned for normal conditions; then exceptional circumstances are supposed (abnormal reduction of passive pressure, accidental overload, etc.) and the calculation is revised, if necessary, in order not to make the material work beyond the limit of elasticity.

H. F. Long, Argentina

2413. Descans, L., Contribution to the calculation of sheet piles, Part II (in French), *Ann. Trav. publics Belg.* **107**, 3, 381–401, June 1954.

This second part is the calculation of a "duc d'Albe," made of steel sheet piles. There are two kinds of "duc d'Albe": (a) one used for protection of beacons, sea marks, etc., against shock of ships, and (b) the other used for mooring of ships. Both types are calculated theoretically, and practical examples are given.

H. F. Long, Argentina

Micromeritics

(See also Revs. 2185, 2196, 2244, 2337, 2400, 2401, 2402, 2403, 2407)

2414. Barth, W., Calculation and design of cyclone collectors based on the latest investigations (in German), *Brennstoff-Wärme-Kraft* **8**, 1, 1–9, Jan. 1956.

Optimum design of cyclones for gas-solids separation provides for maximum particle removal with minimum pressure drop. In addition, small size and large throughput are desirable. Using simplified flow relations, author develops quality factors in the form of nondimensional ratios. These relate cyclone dimensions, fluid properties, and flow data in a meaningful way which permits ready comparison of different types and sizes of cyclones. For example, a loss factor is defined as the ratio of pressure drop across the separator to a velocity pressure which indicates the smallest particle size removed. Several typical examples illustrate the simple calculation procedure. Comparison of calculated and earlier experimental results is fair to good.

E. G. Chilton, USA

Geophysics, Meteorology, Oceanography

(See also Revs. 2126, 2127, 2276)

2415. Levich, V. G., Effect of turbulence on the excitation and at-

tenuation of wind waves on fluid surfaces (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **101**, 4, 615-618, 1955.

Using results attributed to P. L. Kapitza [title source **64**, p. 513, 1949], author compares the rate of supply of energy by the wind, with rate of dissipation by turbulence, in waves of given length and amplitude. This yields an expression for the minimum wind speed causing waves and, for greater wind speeds, the shape of the wave spectrum. Concentrating on the waves of greatest amplitude, the wave velocity, length, and amplitude are obtained. When the wind ceases, the rate of decay of these waves is given in terms of the distance traveled.

Comparison with experimental results is used to fix some unknown coefficients in the theory, and the agreement is then reasonably good.

Reviewer believes there is a numerical slip in Eq. (18).

A. H. Armstrong, England

2416. Baker, G. A., Jr., Mean airflow and heat transport patterns generated by wind machines with applications to frost protection, *Trans. Amer. geophys. Un.* **36**, 6, 954-962, Dec. 1955.

In this paper, theoretical flow patterns are developed for idealization of several types of wind-machine settings of particular interest in the field of the wind-machine protection of fruit orchards from frost damage. From dimensional analysis and asymptotic considerations, a semi-empirical formula is developed for the effective velocity of a turning jet. Author computes the time of arrival of air from a turning jet and, by considering its relation to the transport, establishes a semi-empirical formula relating the thermal response (a measure of the heat transported) to the mean arrival time. From author's summary

Lubrication; Bearings; Wear

(See also Revs. 2220, 2232)

2417. Lewicki, W., Theory of hydrodynamic lubrication in parallel sliding, *Engineer, Lond.* **200**, 5214, 939-941, Dec. 1955.

Author applies Navier-Stokes equation to determine pressure and velocity distributions around leading face of a parallel slider with hydrodynamic lubrication. Resulting equations show that "a purely hydrodynamic friction can be as large as unity"; that "coefficient of friction in a strictly parallel sliding is independent of viscosity, operating velocity, and load"; and that "so-called 'boundary lubrication under extreme pressure' may, more often than not, be entirely hydrodynamical in its nature."

Experimental results confirm theoretical prediction of flow pattern at leading face of slider, and further information on flow pattern is obtained by elastic-plate analogy. T. P. Goodman, USA

2418. Ying, A. S. C., Charnes, A., and Saibel, E., Studies in lubrication XI: Slider bearing with transverse curvature; exact solution, ASME-ASLE Lubrication Conf., Indianapolis, Ind. Oct. 10-12, 1955. Pap. 55-LUB-13, 9 pp. + 1 fig.

An exact solution is developed for the Reynolds equation in the hydrodynamic theory of slider-bearing lubrication with side leakage for film thicknesses varying exponentially both in the direction of motion and symmetrically perpendicular to this direction. This solution is in the form of a rapidly converging series from which calculations for the pressure distribution, total bearing load, frictional force, etc., may be made conveniently for all length-to-width ratios and all center-to-side clearance ratios. The results which were obtained previously by the perturbation method [AMR **6**, Rev. 3955] are shown to be quite accurate for small ratios of center-to-side clearance, and, for larger ratios, the error of the perturbation method is calculated.

From authors' summary by W. O. Richmond, Canada

2419. Savage, R. H., and Schaefer, D. L., Vapor lubrication of graphite sliding contacts, *J. appl. Phys.* **27**, 2, 136-138, Feb. 1956.

A fundamental study of graphite sliding contacts shows that atmospheric concentrations of only a few parts per million of the larger organic molecules are sufficient to prevent the severe wear of graphite which occurs in a dry atmosphere. The experimental results suggest roughly the empirical rule that the minimum relative "humidity" of a vapor for effective lubrication decreases logarithmically with chain length in the region 5 to 15 A. From authors' summary

2420. Cole, J. A., and Hughes, C. J., Oil film extent in complete journal bearings, *Scient. Lubrication*, June 1955.

In a complete (360°) journal bearing, it is difficult to predict the extent of the oil film, particularly when estimating the friction loss. An experimental technique has been developed for photographing the film extent in glass bearings operating under reasonably practical conditions. Photographs are given showing the oil film extent in complete bearings of different forms under various operating conditions, and the results are discussed qualitatively. From authors' summary

2421. Barwell, F. T., and Hughes, M. J., Some further tests on high-speed ball bearings, *Instn. mech. Engrs. Preprint*, 10 pp., 1955.

Friction torque and natural running temperature of 'Light'-type and 'Extra Light'-type bearings of bore 5 in. have been measured at speeds ranging from 5000 to 11,000 rpm. Loads up to 2400 lb were applied at varying incidence of radial to thrust load. Lubrication was by liquid jet at the rate of 6 pints per min. It is concluded that a large proportion of the friction measured under the conditions of lubricant supply adopted in the experiments is attributable to viscous friction in the lubricant. An analysis of the friction torque based on the work of Poritsky, Hewlett, and Coleman (1947) for varying angles of application of load shows no correlation with the experimental results obtained. Estimates of hysteresis loss based on the work of Tabor (1952, 1954) indicate that this factor represents a comparatively small proportion of the total frictional loss of bearings of this type. From authors' summary

Marine Engineering Problems

(See also Revs. 2117, 2276, 2277)

Letters to the Editor

2422. Re AMR 8, Rev. 2286 (August 1955): Nowiński, J., and Olszak, W., On the bases of the theory of physically nonlinear elastic bodies.

The reviewer wishes to replace his previous review with the following:

An analogy between the behavior of elastic-plastic and nonlinear elastic bodies is due to L. M. Kachanov ["Mechanics of plastic media," Leningrad-Moscow, 1948, p. 42 (in Russian)]. This analogy involves the assumptions that there is continued loading and that finite stress-strain relationships govern elastic-plastic deformation. In the present paper, the analogy is the basis of the methods presented for solving problems of nonlinear elastic behavior. Analysis is given of nonlinear elastic behavior for the following problems: bending of beams, bi-axial tension of a plate, and a steadily-rotating disk.

H. G. Hopkins, England

Books Received for Review

CRAEMER, H., Statika tla, Beograde, Gradevinska Knjiga Izdavacko Preduzece Nr Srbije, 1952, iv + 160 pp. (paperbound).

Boundary layer effects in aerodynamics, Proceedings of a symposium held at the National Physical Laboratory on 31 March & 1 April 1955, London, Her Majesty's Stationery Office, 1955, 405 pp. £1, 10s. (paperbound).

DONATO, L. F., Lezioni di scienza delle custruzioni. Parte I. Elementi di teoria dell'elasticità resistenza dei materiali, 3rd ed., Pisa, Editore Colombo Cursi, 1955, ix + 282 pp. L. 3200 (paperbound).

FULLER, D. D., Theory and practice of lubrication for engineers, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1956, xiii + 432 pp. $10.50.

HARTREE, D. R., Numerical analysis, corr. 1st ed., New York, Oxford University Press; Oxford, The Clarendon Press, 1955, xiv + 287 pp. $4.80.

KUHN, P., Stresses in aircraft and shell structures (McGraw-Hill Publications in Aeronautical Science), New York, Toronto, London, McGraw-Hill Book Co., Inc., 1956, xx + 435 pp. $14.

MILNE-THOMSON, L. M., Theoretical hydrodynamics, 3rd ed., New York, The Macmillan Company, 1955, xxi + 632 pp. $9.80.

MUCKLE, W., Modern naval architecture, New York, The Philosophical Library, Inc., 1956, vi + 154 pp. $4.75.

NIELSEN, K. L., Methods in numerical analysis, New York, the Macmillan Company, 1956, xiii + 382 pp. $6.90.

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INDEX OF AUTHORS REFERRED TO IN THIS ISSUE

(NUMBERS USED ARE SERIAL NUMBERS OF REVIEWS)

Aiken, W. S., Jr. 2345
Alexander, E. 2228
Alverman, W. 2324
Amme, R. C. 2351
Anderson, A. B. C. 2349, 2398
Anderson, M. S. . . 2166, 2197
Anderson, R. A. 2197
Aniansson, Gunnar 2332
Aniansson, Gustaf 2332
Arvay, L. 2339
Bailey, H. E. 2310
Baker, G. A., Jr. 2416
Bandyopadhyay, G. 2076
Banerji, S. K. 2091
Barrett, M. 2400
Barth, W. 2414
Barwell, F. T. 2421
Beer, H. 2181
Beisswanger, H. 2231
Benson, R. S. 2327
Benton, G. S. 2251
Berger, H. M. 2153
Berman, A. 2302
Besseling, J. F. 2174
Bland, D. R. 2209
Blehman, I. I. 2107
Bogdonoff, S. M. 2260
Boley, B. A. 2110
Bolotin, V. V. 2161
Botman, M. 2174
Botzen, A. 2353
Boult, G. T. 2382
Bradistilov, G. 2109
Brekhovskikh, L. M. . . . 2392
Brillouin, J. 2390
Broberg, K. B. 2198
Brodeau, A. 2119
Broglio, L. 2129
Brokaw, R. S. 2366
Brombacher, W. G. . . . 2328
Brun, R. J. 2256
Bryant, R. A. A. 2341
Bukovics, E. 2087
Bull, T. H. 2237
Bullard, E. 2246
Burger, A. P. 2308
Burshtein, E. 2127
Burton, J. T. A. 2352
Callahan, W. R. 2112
Campbell, I. J. 2267
Campbell, J. D. 2149
Carlson, R. L. 2218
Carp, H. 2223
Carpenter, P. J. 2301
Cartwright, D. E. 2276
Chamberlain, J. W. . . . 2286
Chamecki, S. 2406
Chandrasekhar, S. 2247
Charnes, A. 2416
Chatynian, L. A. 2206
Chauvin, L. T. 2344
Cheek, R. E. 2407
Chernyi, G. G. 2282
Chilver, A. H. 2170
Cohen, C. B. 2370
Cole, J. A. 2420
Colner, W. H. 2208
Colonnetti, G. 2128
Conrad, O. 2135
Conte, S. D. 2085
Continentino, L. 2408
Conway, H. D. 2137
Cox, J. A. M. 2353
Crenshaw, W. P. 2309
Csonka, P. 2168
da Costa Nunes, A. J. . . 2408
Daley, B. N. 2292
Datsev, A. B. 2363, 2364
Davidenkov, N. N. 2201
DeCarlo, C. R. 2088
de Carvalho Lopes, J. . . 2408
Deissler, R. G. . . 2377, 2379
Delsasso, L. P. 2391
Denke, P. H. 2182
Deresiewicz, H. 2114
Descans, L. 2412, 2413
Devienne, F. M. 2359
DeZubay, E. A. 2387
D'iachenko, P. E. 2204, 2206
Diaconis, N. S. 2373
Dick, R. S. 2292
Diehl, E. J. 2335
Dimentberg, F. M. 2146
Dods, J. B., Jr. 2347
Donovan, W. F. 2239
Duquenne, R. 2294
Eckert, E. R. G. 2381
Eney, W. J. 2215
Enselme, M. 2294
Eppler, R. 2296
Erickson, E. C. O. 2229
Estoque, M. A. 2378
Eubanks, R. A. 2230
Evans, J. S. 2340
Evans, R. H. 2183
Eveson, G. F. 2337
Eyring, H. 2191
Faber, O. 2177
Farrow, B. 2227
Fauquet, A. 2297
Federico, D. 2408
Fenain, M. 2263
Field, J. E. 2210
Foldes, G. 2212
Foltz, C. J. 2333
Fonda, A. G. 2095
Forstat, H. 2376
Fox, E. A. 2319
Fraeys de Veubeke, B. M. 2311
Frame, J. S. 2093
Francis, H. T. 2208
Franke, P. 2240
Frederick, D 2156
Fridman, Ja. B. 2136
Friedman, A. S. 2353
Friedrich, H. 2314
Frohlich, O. K. 2404
Galin, G. Ya. 2133
Garza, A. de la 2077
Germain, P. 2263
Gershuni, G. Z. 2380
Giedt, W. H. 2383
Giese, J. H. 2265
Girkmann, K. 2130
Giulianini, A 2361
Glantz, H. 2083
Gluvchinskiĭ, E. V. 2144
Gol'denblat, I. I. 2192
Goodstein, R. 2106
Granat, Yu. L. 2078
Grandjean, C. 2294
Gregory, C., Jr. 2333
Grib, A. A. 2268
Grodzinski, P. 2211
Grodzovskiĭ, G. L. 2270
Güth, W. 2238
Hagen, J. F. 2235
Hall, E. W. 2337
Hammer, E. W., Jr. . . . 2169
Hammitt, A. G. 2260
Hample, W. G. 2207
Hansen, A. G. 2252
Hantush, M. S. 2258
Haringx, J. A. 2151
Hartnett, J. P. 2369
Head, J. W. 2079
Heiba, A. E. 2115
Helmbold, H. B 2295
Henrici, P. 2086
Herrmann, G. 2113
Herzig, H. Z. 2252
Hieke, M. 2139
Hinchliff, S. 2236
Hinkle, R. T. 2093
Hodge, P. G., Jr. 2186
Holzmann, E. G. 2358
Hopkins, H. G. 2157
Hoskin, B. C. 2163
Houbolt, J. C. 2303
Huckel, V. 2305
Hughes, C. J. 2420
Hughes, M. J. 2421
Hyler, W. S. 2217

(Continued on outside back cover)

INDEX OF AUTHORS REFERRED TO IN THIS ISSUE (*Continued*)

(NUMBERS USED ARE SERIAL NUMBERS OF REVIEWS)

Il'yushin, A. A. 2188
Ip, C. 2093
Isakovich, M. A. 2395
Ivanov, I. D. 2392
Iversen, H. W. 2329
Jack, J. R. 2373
Jackson, H. H. 2344
Jacob, C. E. 2258
Jaffe, L. D. 2200
Jain, M. K. 2195
Jindra, F. 2131
Johnson, E. E. 2165
Johnson, J. W. 2176
Johnson, R. C. 2147
Jones, J. W. 2236
Jones, R. T. 2289
Jordan, P. F. 2304
Jorissen, A. L. 2330
Jumikis, A. R. 2409
Jürgen, L. 2324
Karas, K. 2118
Karol, R. H. 2399
Katzen, E. D. 2293
Keates, R. E. 2273
Keenan, J. H. 2356
Kestner, O. E. 2206
Ketchum, V. 2175
Keusch, R. B. 2326
Keyes, F. G. 2356
Klebanoff, P. S. 2285
Klein, B. 2155
Klemp, W. 2180
Knickrehm, H. 2325
Knuchel, H. 2225
Koenig, J. H. 2222
Kollár, L. 2145
Kononenko, V. O. 2108
Korsakevich, N. I. 2144
Korvin-Kroukovsky, B. V. 2277
Koshelev, A. I. 2134
Kraus, W. 2367
Krettner, J. 2138
Kreuter, K. 2315
Kromm, A. 2158
Kuchemann, D. 2291
Kugel', R. V. 2199
Kuhn, R. E. 2290
Kuhne, H.-J. 2233
Kumai, T. 2117
Lachmann, G. V. 2283
Ladanyi, D. J. 2386
Landdeck, N. E. 2143
Lapturev, N. V. 2242
Laufer, J. 2255, 2280
Laurence, J. C. 2375
Lebedeva, F. B. 2203
Lee, E. E., Jr. 2301
Lee, E. H. 2209
Lees, S. 2103
Legendre, R. 2259
Legvold, S. 2351
Letov, A. N. 2099
Levich, V. G. 2415
Lewicki, W. 2417
Lewin, M. 2228
Lewis, B. 2385
Lewis, E. V. 2277
Lewis, R. G. 2267
Lewis, W. 2256
Li, C. Y. 2410
Libby, P. A. 2371
Lindberg, E. E. 2235
Lindblad, A. 2164
Lissner, H. R. 2140
Livingood, J. N. B. 2381
Loeffler, A. L., Jr. 2379
Loewer, A. C., Jr. 2215
Lohse, W. 2324
Loos, H. G. 2250
Lotkin, M. 2089
Lubahn, J. D. 2214
Ludwig, N. 2216
Lüpke, H. 2323
Lyamshev, L. M. 2394
MacDonald, R. J. 2218
Maggiolo, O. J. 2116
Magnus, K. 2101
Malavard, L. 2294
Malmquist, L. 2357
Mangham, E. 2312
Mangler, K. W. 2281
Manson, N. 2354
Marklund, T. 2388
Marson, G. B. 2272, 2273
Massera, J. L. 2116
Maude, A. D. 2338
McCormick, B. W. 2257
McDonald, P. H., Jr. 2111
Menzie, D. E. 2407
Meyerhof, G. G. 2402
Michels, A. 2353
Miller, R. O. 2386
Milne, R. D. 2307
Mindlin, R. D. 2114
Mirsky, I. 2113
Mitchell, J. L. 2348
Mitterlehner, G. 2148
Moiseev, N. N. 2121
Monroe, E. S., Jr. 2331
Morgan, V. A. 2179
Morris, A. L. 2360
Morris, J. 2079
Morrow, C. T. 2122
Mossakovskiĭ, V. I. 2132
Muchmore, R. B. 2122
Muhlhausen, E. K. 2215
Müller, W. 2138
Munk, M. M. 2287
Murdock, J. W. 2333
Mushtari, Kh. M. 2172
Muster, D. 2230
Narasimhan, R. K. 2076
Nasitta, Kh. 2159
Nelson-Skorniakov, F. B. 2185
Newmark, N. M. 2126, 2150, 2154
Niedzwiedzki, A. 2234
Nisnevich, A. I. 2204
Noren, O. 2332
Norris, C. B. 2171, 2229
Norton, J. T. 2221
Nylander, H. 2173
Oguchi, H. 2261
Ohde, J. 2405
Oliver, J. 2125
Ostrach, S. 2372
Oswatitsch, K. 2262
Owens, R. H. 2124
Pai, S.-I. 2249
Parlett, L. P. 2350
Patterson, R. T. 2090
Peace, A. 2312
Pease, R. N. 2385
Peck, R. F. 2348
Perry, C. C. 2140
Pestel, E. 2142
Peter, Y. 2403
Peters, R. W. 2213
Petersen, R. E. 2169
Petrov, V. V. 2100
Philip, J. R. 2362
Phinney, R. E. 2310
Plaskowski, Z. 2299
Plishkin, Yu. M. 2102
Plunkett, R. 2123
Plymale, B. T. 2106
Prager, W. 2157
Prasse, E. I. 2381
Press, F. 2125
Preston, C. 2220
Queijo, M. J. 2298
Radok, J. R. M. 2163
Rainbow, H. S. 2313
Rakhmatulin, Kh. A. 2393
Ree, T. 2191
Reeber, R. 2098
Reeves, R. F. 2085
Reisinger, F. 2181
Reissner, E. 2083
Reshotko, E. 2370
Reynolds, C. A. 2376
Rhees, T. R. 2309
Riabinin, A. G. 2268
Ribaud, G. 2354
Richards, R. L. 2336
Richardson, E. G. 2278
Ripling, E. J. 2202
Roberts, P. H. 2286
Rose, W. 2400
Rossing, T. D. 2351
Rowlinson, J. S. 2355
Rumiantsev, V. V. 2096
Rumsey, C. B. 2344
Russenberger, M. 2212
Sabol, A. P. 2340
Sachenkov, A. V. 2172
Saibel, E. 2418
Sandborn, V. A. 2375
Sattler, K. 2190
Savage, R. H. 2419
Savic, P. 2382
Schaefer, D. L. 2419
Scholz, N. 2321
Schubauer, G. B. 2285
Schulz, G. 2300
Seborg, R. M. 2226
Sejournet, J. 2232
Semenov, M. V. 2094
Sen Gupta, A. M. 2162
Shafer, S. N. 2123
Shamanskiĭ, V. E. 2084
Shapiro, I. G. 2269
Shapiro, N. M. 2374
Shearer, J. L. 2104, 2105
Shercliff, J. A. 2248
Sherman, D. I. 2160
Sherman, F. S. 2342
Shield, R. T. 2189
Shiloh, M 2228
Shivers, J. P. 2301
Shmakov, M. I. 2184
Shor, G. I. 2203
Sibulkin, M. 2274
Siebel, E. 2216, 2231
Simmons, W. F. 2217, 2218
Sinnot, C. S. 2275
Sknar, N. A. 2318
Slobodianskiĭ, M. G. 2081
Smiley, R. F. 2303
Smith, J. F. 2328
Smoke, E. J. 2222
Sobolev, N. D. 2136
Socha, W. 2273
Sokolovskiĭ, V. V. 2187
Solov'ev, L. 2127
Spahr, J. C. 2336
Spengler, W. 2334
Stamm, A. J. 2226
Stavrogin, A. N. 2201
Stewart, W. L. 2317
Stickney, T. M. 2384
Strigl, G. 2092
Stüper, J. 2279
Symonds, P. S. 2124
Talbot, L. 2271
Tao, L. N. 2239
Taraĭmovich, I. I. 2243
Tatnall, F. G. 2141
Taylor, H. S. 2385
Terletskaia, M. N. 2401
Thamm, I. 2097
Thomas, N. 2397
Tidstrom, K. D. 2285
Tinling, B. E. 2347
Trumpler, W. E., Jr. 2319
Tsai, D. H. 2322
Tsobkallo, S. O. 2120
Tung, T. P. 2126
Turkalp, I. 2167
Ulanov, G. M. 2100
Vainshtein, V. E. 2205
Van der Pyl, L. M. 2328
Van Manen, J. D. 2343
Vargas, M. 2408
Vasarhelyi, D. 2167
Vernotte, P. 2368
Vincenti, W. G. 2346
Visich, M., Jr. 2264, 2371
Visser, H. 2335
Volterra, E. 2230
von Karman, T. 2288
Voronovskaia, E. V. 2080
Wadhwa, Y. D. 2284
Wahl, A. M. 2152
Walls, J. H. 2303
Weil, N. A. 2150, 2154
Weltmann, R. N. 2196
Wemelsfelder, P. J. 2365
Werth, G. C. 2391
Whitmarsh, G. E. 2306
Whitmore, R. L. 2338
Wiener, B. 2345
Willcox, F. G. 2307
Wilson, C. D. 2320
Winter, E. F. 2389
Wood, R. H. 2178
Yakubovich, V. A. 2082
Yamamoto, Y. 2193
Yih, C.-S. 2253, 2254
Ying, A. S. C. 2418
Yur'ev, I. N. 2266
Zaslavski, Yu. S. 2203
Zhukov, A. M. 2194
Zhukovskiĭ, M. I. 2318
Zickuhr, W. 2316
Ziebland, H. 2352
Zienkiewicz, O. C. 2241
Zink, H. 2396
Zot'ev, A. I. 2219
Zusin-Molozhen, L. M. 2269